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Ambient Positional Instability Among Teachers in Minnesota Public Schools: 2010-2011 to 2014-2015

Farah Rayes
University of Pennsylvania

Jimin Oh
University of Pennsylvania

Selene Lee
University of Pennsylvania

Robert Boruch
University of Pennsylvania, robertb@gse.upenn.edu

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Abstract

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The purpose of this paper is to examine teacher retention and churn in the state of Minnesota from 2010 to 2015. Specifically, this paper examines 1) the retention of full-time public school teachers at the state level, district level, and school level, 2) teacher cohort retention trends in different subjects and grade levels, and finally, 3) teacher retention in the 5 largest districts of Minnesota. To analyze these issues, publicly-accessible administrative data on education staff in Minnesota from 2010 to 2015 was used.

This paper proceeds as follows. First, the rationale of the API project is described. Some of the reasons for teacher retention and churn are explored and the consequences of high teacher churn and turnover are explained. Next, detailed description of the data structure, our considerations in deciding how to reconfigure the data, and the process of data reconfiguration are described. Here, we also explain the challenges we faced while working with the data files. Thereafter, the findings regarding the three issues mentioned above are summarized. Finally, the conclusions drawn from the analysis and our next steps are presented.

Disciplines
Education | Educational Assessment, Evaluation, and Research

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2010-2011 to 2014-2015

Farah Rayes, Jimin Oh, Selene Lee, and Robert Boruch

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I. INTRODUCTION

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II. RATIONALE OF THE API PROJECT

High teacher instability, caused by teachers who leave the job permanently or change schools, has the potential to compromise the right of every student in the United States to be educated well (Loeb, Darling-Hammond & Luczak, 2005; Ronfeldt, Loeb & Wyckoff, 2013). The National Commission on Teaching & America's Future (NCTAF) referred to this phenomenon as a "crisis" for the U.S. education system (Boe, Cook, & Sunderland, 2008, p.7). In fact, in the 2011-2012 school year, the U.S. Department of Education (DOE) reported that out of 3,377,900 K-12 teachers in the United States, around 271,900 teachers transferred from one school to another and around 259,400 left the profession (Goldring, Taie, & Riddles, 2014). In other words, about 15% of the K-12 teachers in the United States had either changed the school where they worked or left their job that year.

Although a number of studies provide valuable information on teacher instability, they only partially explain the dynamics of movement within the teaching profession. Some researchers have argued that differentiating between the types of teacher instability is needed to capture the dynamics involved (Grissom, Viano, & Selin, 2015). This differentiation is important because different types of indicators can explain teacher movement in different ways. For example, teachers leaving the teaching profession entirely, also known as attrition, are different from teachers who change schools (Kulka-Acevedo, 2009) within the district or between districts (Goldhaber, Gross, & Player, 2011). In addition, teacher instability is not limited to attrition and transfer between schools. For example, teachers who stay in the same school but change assignments, grades or subjects should also be considered (Ruby, 2002). Therefore, a more nuanced approach is needed to properly capture the dynamics of each type of teacher instability, including teacher attrition and teacher mobility between and within schools.

Another limitation is that only a few studies have used long-term longitudinal data to properly track the movement of teachers (Borman & Dowling, 2008). For example, Borman and Dowling (2008) conducted a meta-analysis of 34 studies regarding teachers' career trajectories. They found that only a few studies used national-level, long-term longitudinal data that can explain the dynamic trajectories of teacher career paths. Many studies typically used national datasets such as the School and Staff Survey (SASS) and Teacher Follow-up Survey (TFS) which captured year-to-year attrition and mobility. As these datasets describe teachers at only one point in time, it is not possible to examine teachers' trajectories longitudinally (Borman & Dowling, 2008; Kukla-Acevedo, 2009).

Due to the limitations mentioned above, we depend here on a different term that better covers the dynamics of teacher instability. Ambient Positional Instability (API) is a term that includes not only teacher attrition, but also teacher movement in various aspects across years and within a year (Boruch, Merlino, & Porter, 2014). For our API project, our team used five years of administrative data which contain information on the teacher population in the state of Minnesota.

III. LITERATURE REVIEW ON TEACHER RETENTION AND CHURN

In this section, we investigate the literature on teacher retention and churn to find answers as to why teachers decide to change schools or leave the profession, and how teacher instability impacts education in the United States.

Reasons for teacher retention and churn

Retirement. One of the reasons that teachers decide to leave their positions is retirement. In particular, many baby boomers retired during the 2000's. According to U.S. Census Bureau, it was estimated that teachers over the age of 50 who were near retirement composed 30% of the

total teacher population in the 2000's (Aaronson, & Meckel, 2009). Also, Carroll and Foster (2010) estimated that in the 2003-2004 school year, 48% of teachers were in their late 40s and, considering that the average retirement age of a teacher is 59 years, retirement could cause a shortage of teachers in 10 to 20 years. If a large chunk of experienced teachers retire, their jobs are usually filled by inexperienced new teachers who are often considered to be less effective in their teaching, which can cause a decrease in the quality of education for their students.

Retirement, however, is inevitable but predictable (Carroll & Foster, 2010). More significant problems are triggered by teachers who change jobs from school to school or district to district, as well as by those leaving the teaching profession altogether before retirement age (Ingersoll, 1997; Ingersoll, 2001; NCTAF, 2003). Boe et al. (2008) analyzed 10 years of the Teacher Follow-up Survey and found that the major reason for teachers leaving their position was not retirement (16%) but job dissatisfaction or to pursue another job (36.7%).

Individual factors. Other factors that determine teacher instability are teachers' individual characteristics. For example, age, experience, qualification and subjects taught are considered to be important factors that influence teachers' decisions on changing or leaving their job. There is substantial evidence to suggest that teachers' demographic characteristics are closely associated with their likelihood of changing or quitting their position (Ingersoll, 2001). In particular, a teacher who is young, close to retirement, and teaching certain subjects (i.e., special education, math and science) or less qualified has a higher probability of changing jobs.

Studies about teachers' age and experience have shown consistent patterns - there is high instability among new teachers and those near retirement age. Blazar (2014), for instance, studied a 10-year panel of administrative data (2002 to 2013) of elementary school teachers in an urban area in California and found that teacher instability increased among teachers with two to four

years of teaching experience and then decreased with further experience. He also found that the trend again increased around retirement age. Kulka-Acevedo (2009) also examined the 1999-2000 School and Staff Survey and 2000-2001 Teacher Follow-up Survey data and found similar patterns. He confirmed that novice teachers were 1.5 to 2 times more likely to quit the profession or move to other schools than experienced teachers. This U-shaped pattern of attrition by years of experience (i.e., higher instability for the less and more experienced teachers) may occur because new teachers are often under-prepared and lack support (Ingersoll, 2001), while the pension systems may stimulate older teachers to retire earlier than other professions (Harris & Adams, 2007).

Another factor that influences teacher instability is the subjects that a teacher teaches. Although studies showed some mixed results, many researchers have found that special education teachers, math teachers, and science teachers, in particular, are more likely to change jobs. For example, Kulka-Acevedo (2009) found that teachers who majored in math and science, especially those who taught in secondary schools, were more prone to leaving their jobs because they had other opportunities to use their knowledge and skills. On the other hand, there are researchers who present evidence that there are not many differences regarding teacher instability between teachers who teach math and science versus other subjects (Bowdon & Boruch, 2014; Ingersoll & May, 2012). An API project in Missouri (2014) found that the instability in subjects taught was very similar for math, science, English and social studies. This discordance may be due to the fact that math and science teachers have more autonomy in teaching, and often have higher salaries than English or social studies teachers (Ingersoll & May, 2012).

Finally, teacher quality is critical for explaining teacher instability. Although the definition of teacher quality varies across studies (Blazar, 2015; Goldhaber et al., 2011) and is very

ambiguous, it is often measured by experience, education, certification, teacher achievement, and student achievement. Borman and Dowling (2008) found that the likelihood of quitting was higher amongst teachers who were relatively less qualified (i.e., those who only had a bachelor's degree and regular certification and those who scored relatively low on some standardized tests).

Organizational factors. Organizational conditions can also influence teacher retention and churn. Negative school characteristics and working conditions such as lack of administrative support, education resources, and autonomy, as well as high poverty among students can increase teacher attrition and turnover (Borman & Dowling, 2008; Ingersoll, 2001; Keesler & Schneider, 2010; Loeb, Darling-Hammond, & Luczak, 2005). By examining these organizational conditions, one can explain some of the reasons behind inter-district and intra-district migration among teachers (Goldhaber et al., 2011; Imazeki, 2005).

School location is also important, as many school districts are divided along socio-economic and ethnic lines. Schools in urban and rural areas often serve more low-income and minority students, have higher teacher instability, and are more likely to suffer from teacher shortage compared to suburban areas (Guin, 2004; Imazeki, 2005). Guarino et al. (2006) indicated that schools in urban areas and schools with a high proportion of minority students found it difficult to fill teacher vacancies. If there is a low supply of teachers in a high-poverty neighborhood, it leads to increased class size, reduced expenditure per pupil, and the hiring of less-qualified substitute teachers, which all have negative effects on students' educational experiences.

Another important factor is teachers' salaries. Many economists studied the relationship between higher teacher salaries and teacher retention. In general, researchers agreed that teacher salary is negatively associated with teacher instability (Garcia, Slate, & Delgado, 2008; Loeb et al., 2005). For example, Hanushek and his colleagues (1999), using panel data from Texas (as cited

in Loeb et al., 2005), found that if a district increases teacher salaries, teachers in that district are 10% less likely to leave the district.

Some researchers have also pointed out the importance of administrative support and autonomy within the school. One study that showed the importance of school administrators was conducted by Boyd and his colleagues (2009). They conducted multinomial logistic regression analyses using self-reported survey data from all of the first-year teachers who worked in New York ($N = 4,360$). They found that school conditions (such as teacher influence, staff relationship, and teachers' perception of administration, student, faculty and safety) were important factors for predicting instability in the profession. In particular, teachers who had a less positive perception of their school administrators were more likely to move to another school or to quit the profession. Jackson (2012), using the 1999-2000 School and Staff Survey, also found that an increase in teacher influence over the school's policy decisions was positively correlated with job stability, whereas administrators' influence over school policy was negatively correlated with job stability.

Consequences of high teacher churn

High teacher instability, it has been argued, can harm students' educational experiences and results in lower student achievement. High churn among teachers can cause issues such as curriculum incoherence, lack of quality instruction and inefficient use of resources, which can all compromise children's educational experiences (Loeb, Darling-Hammond & Luczak, 2009; Ronfeldt et al., 2013). In fact, Ronfeldt et al. (2013) investigated 4th and 5th graders' achievement in New York public schools over eight years. They found that students in schools with high instability among teachers scored lower on both English and math than schools with high teacher retention or low churn. This may be because less-qualified teachers tend to have higher instability than more-qualified teachers (Blazar, 2014; Goldhaber et al., 2011), and students who studied

under more-qualified teachers tend to score better (Rockoff, 2004).

Moreover, instability of the teaching workforce can negatively impact the various efforts for improving schools. Many school reform initiatives and related experiments may lose their full impact as a result of high teacher instability. For example, large-scale randomized control trials that operate in multiple sites in the U.S. must somehow anticipate and handle teacher attrition (Bowdon & Boruch, 2014; Ye et al., 2015). This is because when a teacher leaves a school, they may take their pedagogical knowledge and skills with them (Synar & Maiden, 2012). Also, teachers who stay in schools with high teacher instability are more likely to decide to move or quit in the future. That is, individual teachers' decisions on changing or quitting their positions can also influence other teachers' decisions to leave and, eventually, reduce the effect of education reforms. Ruby (2002) argued that this instable trend among teachers might lead to a net loss of the effectiveness of school reforms by reducing the quality of communication among employees, as well as by reducing the cooperation among employees.

Lastly, high teacher instability is financially costly. Although the range of estimates vary from study to study, schools and districts pay approximately up to $2 billion annually for teacher instability (Ingersoll & Perda, 2009). This cost includes the expenses for recruiting new teachers and training them until they assimilate to their new environment and reach their maximum effectiveness (Synar & Maiden, 2012). This high cost is a problem, because the cost is distributed unequally across districts. Some researchers found that the estimated costs for high-poverty, urban school districts can be up to two or three times higher than their counterpart districts in low-poverty, suburban districts (Barnes, Crowe & Schaefer, 2007; Ingersoll & Perda, 2009). As poor districts have more limited resources, expenditure for teacher instability prevents the distribution of these resources to where it is truly needed.

In conclusion, there are many factors related to teacher instability. These significantly compromise the nation's efforts to improve the education system. An isolated approach to tackling teacher retention and attrition may not be effective. Evidence suggests that it is very difficult to improve the retention of high-quality teachers without rigorous reform in the organization, management, and funding of public schools (Boe, Cook & Sunderland, 2008). Therefore, teacher retention policies should be considered as part of the entire process of constructing a quality education system, rather than an isolated problem of education in the United States.

IV. EDUCATION IN MINNESOTA

Minnesota has a reputation of having a relatively well-established education system. It has high-achieving students when compared nationally and internationally. For instance, after Massachusetts and Vermont, students in Minnesota received the highest scores in the Trends in International Mathematics and Science Study (TIMSS) among 8th graders in the country in 2011. In addition, compared to 38 other countries and some big cities (e.g. Quebec and Dubai), students in Minnesota were ranked 8th place on the TIMSS (Ryan, 2013). In 2014, the biggest cities of Minnesota, Minneapolis and St. Paul had literacy rates that were among the highest in the country (Miller, 2014). This achievement may have been possible due to the maintenance of high teacher quality (Darling-Hammond, 2000).[1]

V. DATASET FROM MINNESOTA

Administrative data used in the analysis

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[1] According to Minnesota's Statutes Section 120A.5, "teachers delivering core content instruction must be deemed highly qualified at the local level and reported to the state via the staff automated reporting system."

Administrative data on education staff, students, school finance, etc. can be searched and downloaded from Minnesota's Department of Education website. Among these publicly available files, the *Assignment detail* file was used for the analysis in this paper.[2]

This *Assignment detail* file contains the unique ID number of the staff, assignment code (role of the staff), assignment description, grade(s) the staff worked with, full-time equivalence of the assignment, whether the staff was highly-qualified, whether the assignment was in the Seven County Metro, economic development region, district number, district type, district name, district county ID, district county name, school county ID, school county name, school classification, school number, school name, address, City, State, and zip code. It should be noted that each teacher can have more than 1 assignment, and each assignment is entered on a separate row or record. Different roles (i.e., the staff worked as a librarian and a nurse), different subjects (i.e., the staff taught general biology and life sciences), and different grades (i.e., the staff taught political science to grade 8 and grade 9) are considered to be different assignments.

Data from five academic years (academic year 2010-2011, academic year 2011-2012, academic year 2012-2013, academic 2013-2014, and academic year 2014-2015) was used for the analyses. All of these files were available as Excel files, and the number of records in each file is listed below:

· 2010-2011: 151,043 records

· 2011-2012: 153,549 records

· 2012-2013: 154,147 records

· 2013-2014: 157,840 records

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[2] Minnesota Department of Education. *Data Reports and Analytics: Staff.* Retrieved from: http://w20.education.state.mn.us/MDEAnalytics/Data.jsp (datasets downloaded on October 13 and 20, 2015).

・2014-2015: 160,638 records

Shape of the dataset

The original excel files were stored in a "long format", as shown in Figure 1. This means that every row corresponded to a unique assignment. A unique assignment is defined as a unique set of *Teacher × Year × Grade × Subject × District × School* values.[3] In other words, in long format, the information per teacher is entered over several rows. The number of rows per teacher varies depending on the number of unique assignments a teacher holds over the different years.

	Teacher ID	Year	Grade	Subject	School Code	District Code
One unique teacher	997996	2010	Elementary	Math	107241753010	1074175
	997996	2010	Secondary	Science	107241753010	1074175
	997996	2011	Secondary	Math	107241753010	1074175
One unique teacher	455954	2010	Elementary	English	101208333041	1010833
	455954	2010	Elementary	Math	101208333041	1010833
	455954	2010	Elementary	Social Studies	101208333041	1010833
	455954	2013	Elementary	English	101208333041	1010833
One unique teacher	75403	2010	Secondary	English	101206253579	1010625

Figure 1. Long dataset.
Note: The data in this table is for illustrative purposes only.

The five dimensions used in the analyses in this paper are: Year, Grade, Subject, District, and School. Year has five levels: 2010-2011, 2011-2012, 2012-2013, 2013-2014, and 2014-2015. Grade has two levels: Elementary and Secondary. Subject has six levels: math, English, science, social studies, general education, and foreign languages. District has 2000 levels (number of unique districts), and School has 533 levels (number of unique schools). These dimensions are visually depicted in Figure 2.

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[3] This is a simplified explanation, as the original dataset had more dimensions which were not used in the current analysis.
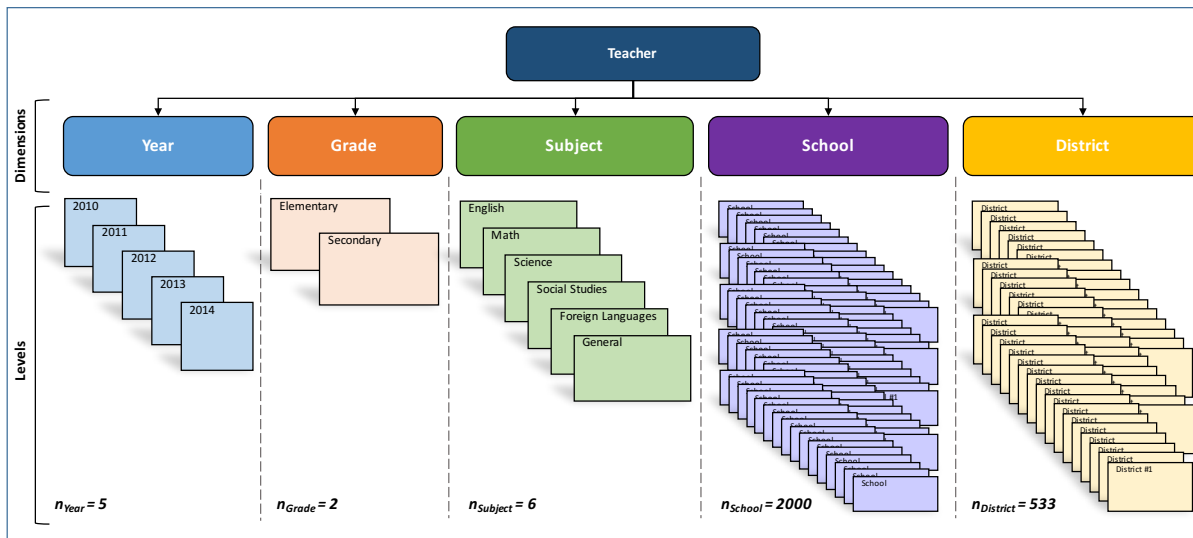
Figure 2. Dimensions and levels in the analysis.

VI. MERGING, EDITING, AND RECONFIGURING THE DATASET

Full-long dataset with teachers of interest only

First, we made a "full-long" dataset which included all the assignments of the teachers to be tracked over the 5 years. The steps for making this dataset are outlined below. *Base SAS 9.2* was used for all the analyses.

Identify the base cohort to be tracked. In this step, the 2010-2011 dataset was used to identify the teachers to be tracked for the retention analyses.

First, only teachers that taught at least 1 of the 6 core subjects (math, science, English, social studies, foreign language, and general education) in 2010-2011 were kept in the dataset. Through this process, all non-teaching staff, as well as teachers who did not teach a core subject were dropped from the dataset.

Next, only teachers who taught in one school in 2010-2011 were kept in the dataset.

Finally, only teachers with a total full-time equivalency value of 0.75 and over in 2010-

2011 were kept in the dataset. It should be noted that the criteria for calculating full-time equivalency was not the same for all schools in the dataset. For example, in some schools, a teacher with full-time equivalency of 1 taught for 25 hours per week, while in other schools, a teacher with full-time equivalency of 1 taught for 30 hours per week.

As a result of these steps, only teachers that taught at least 1 core subject, taught in only 1 school, and had total full-time equivalency of 0.75 and over in 2010-2011 were retained. These teachers constitute the base cohort to be tracked. We pulled out the unique teacher IDs from this file and created a list of the teachers of interest.

Concatenate datasets from all five years and dummy code teachers of interest. In this step, the datasets from all five years were concatenated (i.e., they were combined by stacking the datasets one on top of the other). Also, a new dummy variable was created to identify the teachers of interest. Specifically, teachers that were in the list created in the step above were coded 1 and those that were not were coded 0.

Create a new dataset with the teachers of interest only. In this step, a new dataset was created by selecting teachers that were part of the base cohort only (i.e., those that were dummy coded 1 in the step above). This made it possible to track the changes in the base year cohort over the years. This dataset was used for the retention analyses.

Reconfiguring the dataset

As mentioned above, the dataset created in the step above was stored in a "long format". An alternative to this format was a "wide format" in which each row corresponds to a unique teacher.

Deciding how to reconfigure a dataset is a foundational step for any analyses, because it is difficult to conduct any analysis if the data is not organized properly. This task may seem

deceptively simple. Indeed, when the aim is to analyze two variables (e.g., teacher retention by year), the analysis can be visualized in a tabular format. However, when the number of dimensions and the number of levels within each dimension increases, this task is less straightforward. As this section will point out, there is no format that will work across the board. Instead, it is important to store the original data in a format that can be easily converted to another as needed.

Some advantages and disadvantages of long and wide formats are listed in Table 1 below.

Table 1. Some advantages and disadvantages of long vs. wide format*

	Advantages	Disadvantages
Wide	- In its *simplest format**,* the presentation is more intuitive and easier to understand. - In its *simplest format*, retention and churn are more easily computed.	- Data files can be very large. - The file has many empty cells. - Sub-setting data is more complicated. -Replicating similar analyses is inefficient and prone to errors.
Long	- Sub-setting data is relatively easy (i.e., deleting unwanted observations or rows). - Pulling out relevant dimensions, products of dimensions, and levels of a dimension is relatively easy (i.e., selecting columns). - The file does not have empty cells.	- Teacher information can be spread out over several rows. - Computing retention and churn rates is less direct.

Note: This list is not exhaustive.*
*Note***: By simplest format, we mean that the data can be concisely presented in a table (e.g., a*

Teacher × Year table)

Some important questions to consider prior to choosing a format are:

1) What are the relevant dimensions of the analyses?

2) What are the levels within each dimension?

3) What constitutes a unique assignment?

Other important considerations for choosing a format are:

Space. Bigger files are more difficult to handle. Moreover, large files require more processing time. As this analysis requires processing the files multiple times, the size of the dataset matters.

Ease of analysis. If information on a specific assignment is spread out over several columns, we would first need to identify and pull out the relevant columns and consolidate all the information prior to running any analysis. This is time-consuming and inefficient. We would like to pull out the relevant dimensions easily to answer our various research questions.

Preserving all information. When transforming the dataset from one format to another, a lot of information can be lost if care is not taken. Although this may not be problematic for simple analyses, it can limit what can be done in more complex analyses.

Replicability. In effect, what differentiates one computation from the other is the dimensions being pulled out. The math does not change - the same computations are replicated along different dimensions (e.g., state-level teacher retention), products of dimensions (e.g., teacher retention by subject), and levels of dimensions (e.g., retention of math teachers, science teachers, etc.).

Semi-wide dataset

Due to the considerations mentioned above, we decided to create several small semi-wide

datasets for the different analyses by pulling out the relevant dimensions from the long dataset. For example, to compute state-level teacher retention, we simply pulled out the year dimension. To compute teacher retention by subject, we additionally pulled out the subject dimension. All the relevant dimensions needed for a particular analysis were pulled out from the *same* long dataset.

An example of a semi-wide dataset created from the information in Figure 1 is presented in Figure 4. In a semi-wide dataset, each row does not correspond to a unique teacher. Instead, a unique row will represent a unique assignment, depending on the research question. For example, in the analysis shown in Figure 4, we are not interested in tracking teachers per se; we are interested in tracking teachers by the subjects they taught. Therefore, each row in this file corresponds to a unique *teacher and subject* - if a teacher taught 2 subjects, the teacher is listed in 2 rows.

Teacher ID	Subject	2010	2011	2012	2013
997996	Math	1	1	0	0
997996	Science	1	0	0	0
455954	English	1	0	0	1
455954	Math	1	0	0	0
455954	Social Studies	1	0	0	0
75403	English	1	0	0	0

Unique **Teacher ID + Subject** combination

Figure 4. Semi-wide dataset

This approach is efficient, because we simply need to specify the relevant dimensions to pull out. Moreover, rather than creating new indicators for every analysis, we can simply re-run the programming codes in SAS without creating any permanent indicators or datasets. This approach is also flexible, because it can answer more nuanced research questions. For example, we would easily be able to weight the values in Figure 3 by full-time equivalency and also replicate this analysis for retention by grade, school, district, etc. For this reason, we used semi-wide datasets to conduct all of the analyses in this paper.

Other challenges of working with the dataset

First, the schools in the dataset did not have a unique school number. Specifically, in the raw data files, each school in a *district* within a *district type* had a unique number, which meant that schools in different districts could have the same school number. To solve this problem, the school number was appended to the district number to create a unique school number. However, another problem we faced was that both Minneapolis School District and Aitkins School District had district number 1, so when the district and school numbers were used to generate a unique school number, 5 schools in the Aitkins School District had the same number as 5 schools in the Minneapolis School District. To solve this problem, the district type was appended as well, resulting in a unique school number for all of the schools in the dataset.

Second, 9 districts in the dataset changed name during the years included in the analysis. (Most of them were charter schools that were counted as a unique district.) To verify that the districts sharing the same district code were in fact the same district, they had to be matched using the address, phone number, map, and information on websites and news articles.

Third, there was so much detailed information in the dataset that some information had to be aggregated before conducting the analysis. For example, to calculate the full-time equivalency for each teacher, the full-time equivalency for all of a teacher's assignments had to be summed. Also, to find the teachers that taught a core subject (math, science, English, social studies, foreign language, and general education), the detailed subjects had to be aggregated into the core subjects. For example, 19 subjects related to science, such as biology, chemistry, physics, and astronomy, were aggregated into the subject "science". The list of detailed subjects included in each core subject is presented in Appendix 1.

VII. DESCRIPTIVE STATISTICS

In the base year (2010-2011 academic year), there were a total of 29,377 teachers in Minnesota (this excludes teachers who did not teach any core subjects, teachers who taught in more than 1 school, teachers who had total a full-time equivalency under 0.75, and teachers who only taught in pre-kindergarten and kindergarten). Table 2 shows some descriptive statistics for these teachers.

Table 2. Descriptive statistics of teachers in the base year (2010-2011 academic year)

|		
Total number of teachers		29,377
Subjects	Average number of subjects taught by a teacher	1.04
	Minimum number of subjects taught by a teacher*	1
	Maximum number of subjects taught by a teacher	5
Full-time equivalency (FTE)	Average full-time equivalency (for *core subjects* only)	0.96
	Minimum full-time equivalency (for *core subjects* only)	1.65
	Maximum full-time equivalency (for *core subjects* only)	0.01
Grade level **	Average number of grade levels taught by a teacher	1.01
	Number of teachers that taught in both elementary & secondary school	410 (1.4%)
Percentage of teachers that taught in the 5 main districts		18.4%

Note*: Only 1 teacher taught 5 subjects (this teacher taught elementary science, elementary social studies, elementary math, general elementary education, and elementary reading)
Note **: Elementary K-6 was excluded from this analysis

Figure 5 shows the breakdown of elementary school teachers by subject, and Figure 6 shows the breakdown of secondary school teachers by subject. If a teacher taught in both elementary and secondary school, the teacher was counted in both grade levels. If a teacher taught

more than 1 core subject, the teacher was counted more than once. If a teacher had multiple assignments in the same subject within the same grade level, the teacher was counted only once.
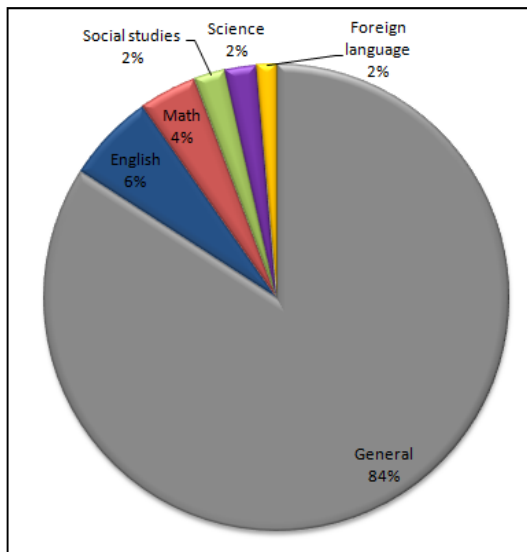
Subject	# of teachers
General education	14,278
English	1,048
Math	682
Social studies	373
Science	371
Foreign language	225
TOTAL	16,977

Figure 5. Elementary school teachers - By subject
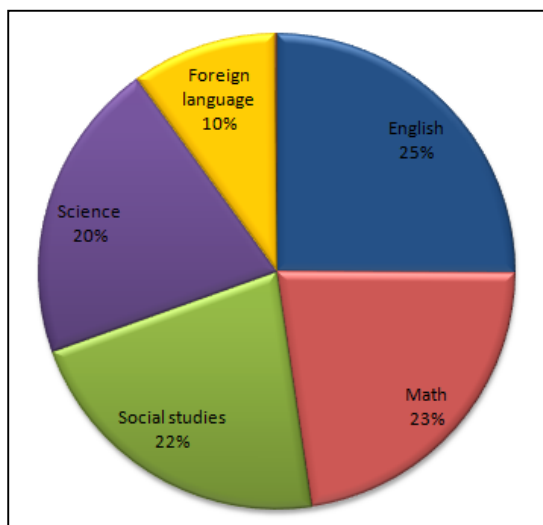
Subject	# of teachers
English	3,302
Math	2,964
Social studies	2,878
Science	2,695
Foreign language	1,295
General education	18
TOTAL	13,152

Figure 6. Secondary school teachers – By subject

VIII. COHORT RETENTION

In this section, we examine the overall cohort retention at the state, district, and school

levels. We then examine cohort retention by subject, specifically, we focus on the cohort of English, foreign language, general education, math, science and social studies teachers. Thereafter, we analyze the retention rate of elementary as compared to secondary school teachers. Finally, we assess retention rates in the five largest districts in Minnesota, namely, the Minneapolis School District, St. Paul School District, Anoka-Hennepin School District, Rosemount-Apple Valley-Eagan School District, and Osseo District School District.

In all the subsequent analyses, the base cohort includes full-time teachers (i.e., with a total full-time equivalency of 0.75 or greater) in Minnesota public schools in the school year 2010-2011. As described above, teachers who did not teach any core subjects, teachers who taught in more than 1 school, and teachers who only taught in pre-kindergarten and kindergarten in the school year 2010-2011 were not considered part of the base cohort. Consequently, they were not tracked.
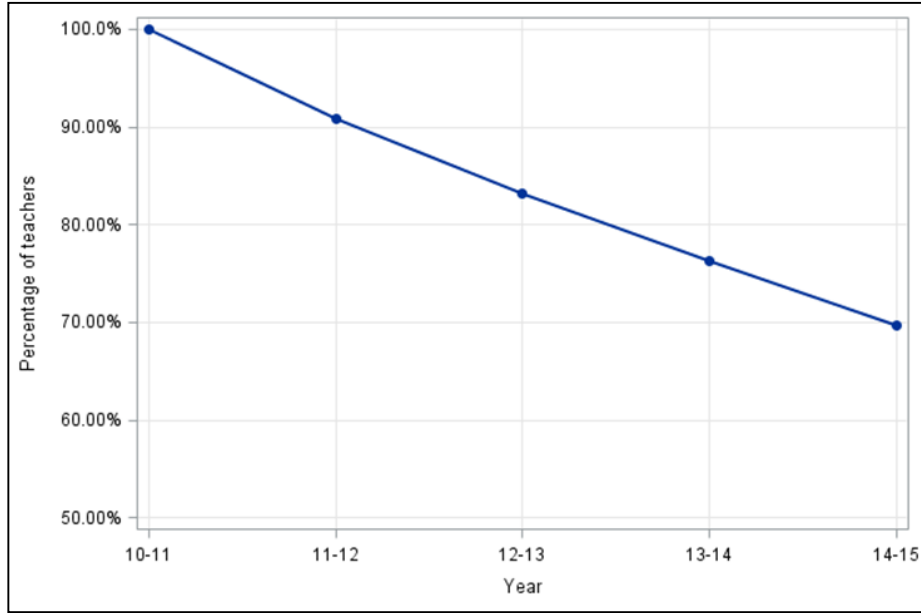
Cohort retention at the state level

The retention rate at the state level is defined as the percentage of teachers in the base year that still had an assignment in Minnesota in subsequent years, regardless of a change in the grade, subject, or full-time equivalency of the assignment. Once a teacher was counted as a *leaver* in one year, the teacher continued to be counted as a *leaver* in all subsequent years.

$$\frac{\textit{Number of teachers who taught in MN}}{\textit{public schools continuously from the base year to year}_i}{\textit{Number of teachers in MN public schools in the base year}}$$

Figure 7 shows the retention rate of teachers at the state level for 4 years following the base year. The cohort retention rate at the state level was 90.8% in year 2, 83.1% in year 3, 76.2% in year 4, and 69.7% in year 5.

	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Cohort retention at the state level	100%	90.8%	83.1%	76.2%	69.7%

Figure 7. Cohort retention at the state level - percentage

Figure 8 shows the number of teachers from the base year cohort that still had an assignment in Minnesota.
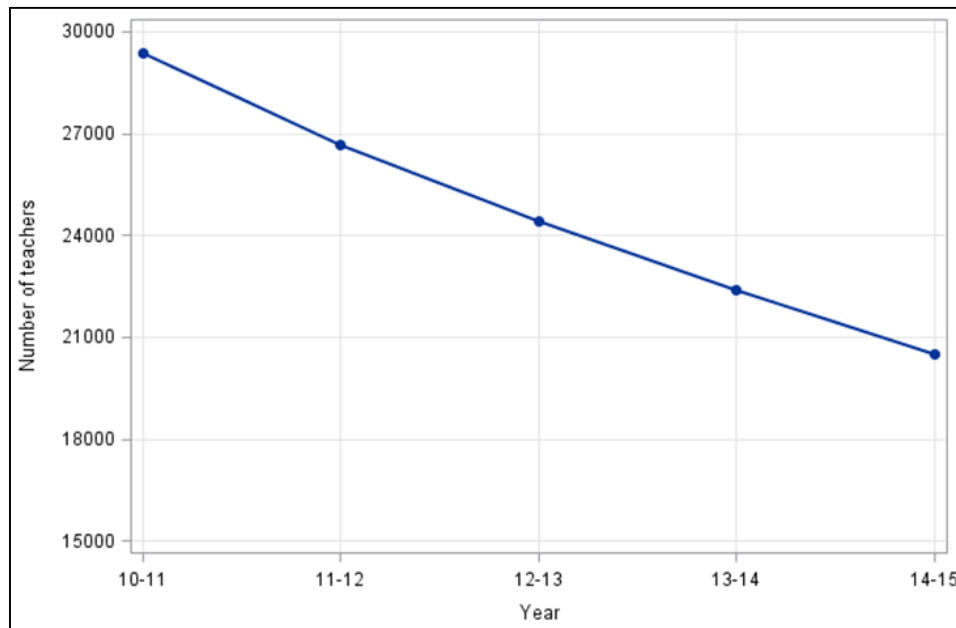
	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Cohort retention at the state level	29,377	26,664	24,421	22,396	20,487

Figure 8. Cohort retention at the state level - number of teachers

Cohort retention at the district level

The retention rate at the district level is defined as the percentage of teachers in the base year that still had an assignment in the same district in subsequent years, regardless of a change in the grade, subject, or full-time equivalency of the assignment. It should be noted that if a teacher had assignments in more than one district in the base year, the teacher was counted more than once in the base year, and their assignments were tracked separately over the years by district. Also, once a teacher was counted as a *leaver* of a district in one year, the teacher continued to be counted as a *leaver* of the district in all subsequent years.

$$\frac{\textit{Number of teachers in MN public schools who taught}}{\textit{in the same district continuously from the base year to year}_i}$$
$$\frac{}{\textit{Number of teachers in MN public schools in the base year}}$$

Figure 9 shows the retention rate of teachers at the district level for 4 years following the base year. The cohort retention rate at the district level was 88.6% in year 2, 80.0% in year 3, 71.9% in year 4, and 64.9% in year 5.
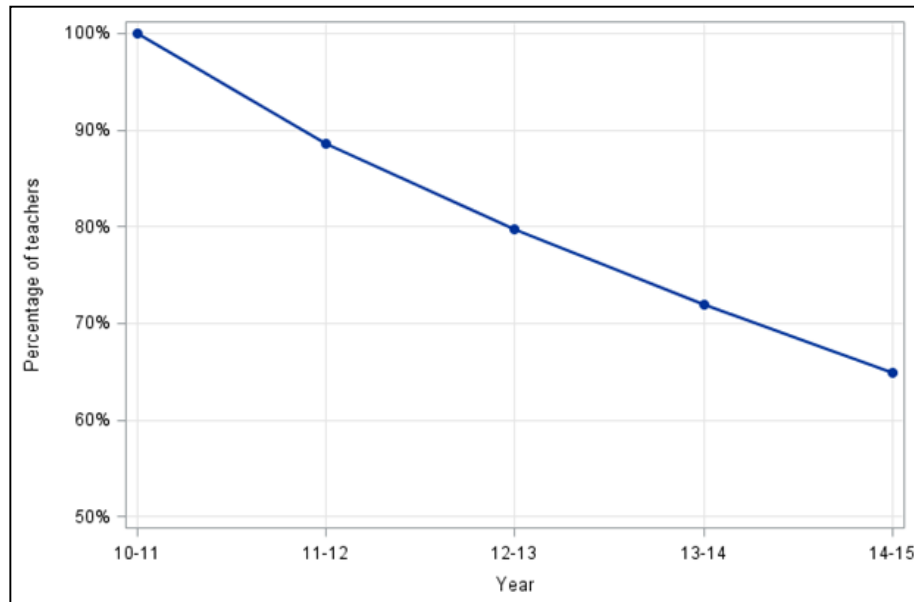
	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Cohort retention at the district level	100%	88.6%	80.0%	71.9%	64.9%

Figure 9. Cohort retention at the district level – percentage

Figure 10 shows the number of teachers each year that still had an assignment in the district they taught at in the base year.

	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Cohort retention at the district level	29,377	26,038	23,402	21,131	19,050

Figure 10. Cohort retention at the district level - number of teachers

Cohort retention at the school level

The retention rate at the school level is defined as the percentage of teachers in the base year that still had an assignment in the same school in subsequent years, regardless of a change in the grade, subject, or full-time equivalency of the assignment. It should be noted that if a teacher had assignments in more than one school in the base year, the teacher was counted more than once in the base year, and their assignments were tracked separately over the years by school. Also, once a teacher was counted as a *leaver* of a school in one year, the teacher continued to be counted as a *leaver* of the school in all subsequent years.

$$\frac{\textit{Number of teachers in MN public schools who taught}}{\textit{in the same school continuously from the base year to year}_{\ i}}{\textit{Number of teachers in MN public schools in the base year}}$$

Figure 11 shows the retention rate of teachers at the school level for 4 years following the

base year. The cohort retention rate at the school level was 84.9% in year 2, 74.5% in year 3, 65.9%
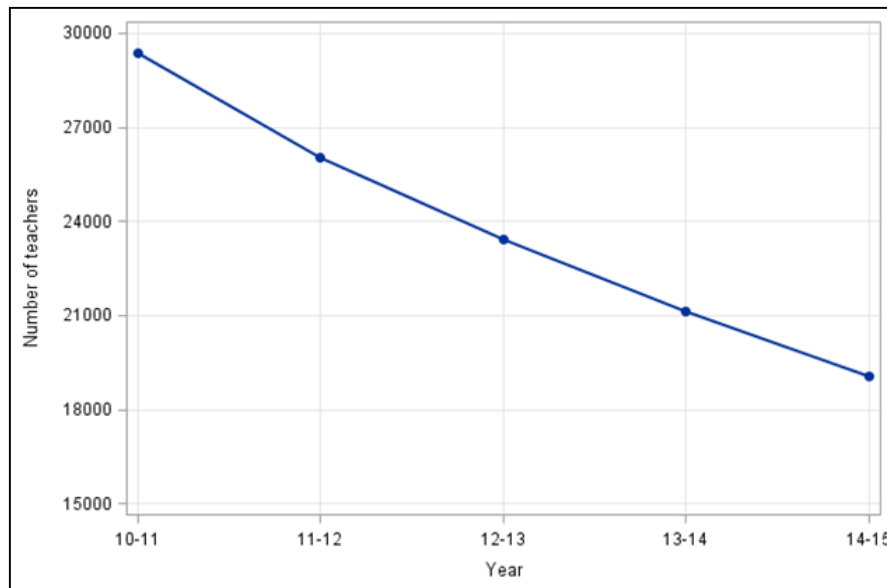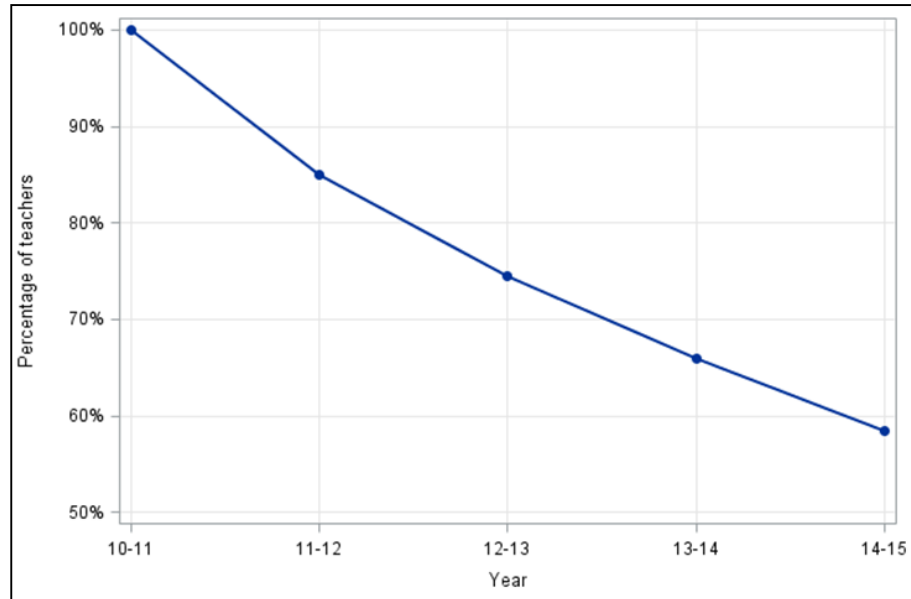
in year 4, and 58.4% in year 5.

	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Cohort retention at the school level	100%	84.9%	74.5%	65.9%	58.4%

Figure 11. Cohort retention at the school level - percentage

Figure 12 shows the number of teachers each year that still had an assignment in the school

they taught at in the base year.
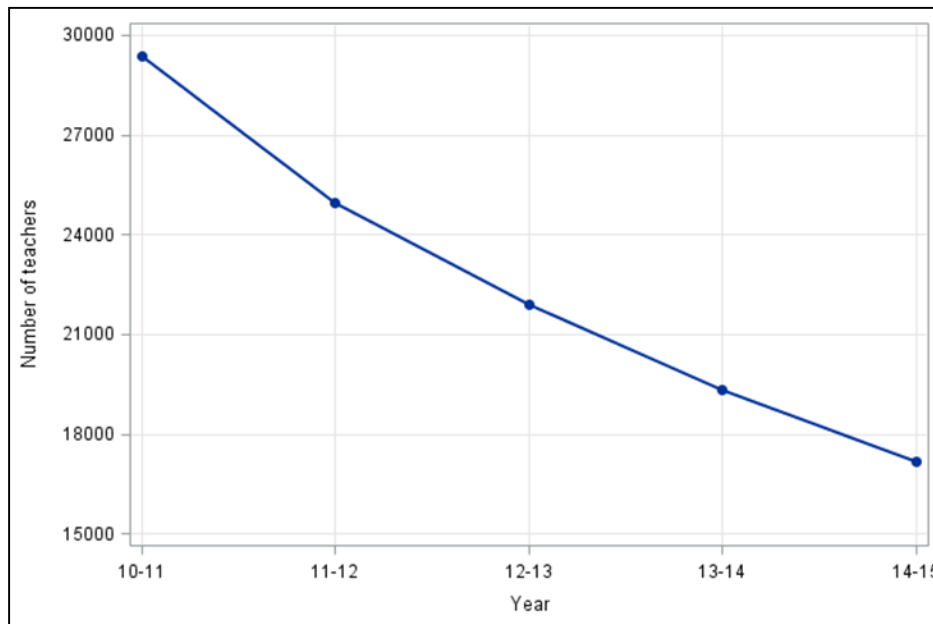
	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Cohort retention at the school level	29,377	24,946	21,897	19,348	17,152

Figure 12. Cohort retention at the school level - number of teachers

Cohort retention by subject

In this analysis, teachers who taught a given subject in the base year (2010-2011 academic year) were considered to be in a subject cohort. Thus, there is a cohort of math teachers, a cohort of science teachers, a cohort of English teachers, a cohort of social studies teachers, a cohort of foreign languages teachers, and a cohort of general education teachers. If a teacher had assignments in more than one of these subjects in the base year, the teacher was included in each of the subject cohorts.

The retention rate is defined as the percentage of teachers in a given subject cohort (which was created in the base year) that still had an assignment in the subject, regardless of a change in the school, grade, or full-time equivalency of the assignment. Once a teacher was counted as a

leaver in one year, the teacher continued to be counted as a *leaver* in all subsequent years. The following six formulae were used to compute the retention of teachers in each subject cohort.

$$(1) \quad \frac{\textit{Number of teachers in MN public schools who taught math continuously from the base year to year}_i}{\textit{Number of math teachers in MN public schools in the base year}}$$

$$(2) \quad \frac{\textit{Number of teachers in MN public schools who taught English continuously from the base year to year}_i}{\textit{Number of English teachers in MN public schools in the base year}}$$

$$(3) \quad \frac{\textit{Number of teachers in MN public schools who taught science continuously from the base year to year}_i}{\textit{Number of science teachers in MN public schools in the base year}}$$

$$(4) \quad \frac{\textit{Number of teachers in MN public schools who taught social studies continuously from the base year to year}_i}{\textit{Number of social studies teachers in MN public schools in the base year}}$$

$$(5) \quad \frac{\textit{Number of teachers in MN public schools who taught foreign language continuously from the base year to year}_i}{\textit{Number of foreign language teachers in MN public schools in the base year}}$$

$$(6) \quad \frac{\textit{Number of teachers in MN public schools who taught general education continuously from the base year to year}_i}{\textit{Number of general education teachers in MN public schools in the base year}}$$

Figure 13 shows the retention rate of each subject cohort for 4 years following the base year. In general, each year, science had the highest cohort retention rate (80% in year 5), followed by social studies (68% in year 5), math (66% in year 5), general education (64%), foreign language (59% in year 5), and English (58% in year 5).

General education had the second highest cohort retention rate in year 2 (89%), which dropped to the third highest cohort retention rate in year 3 (80%), which again dropped to the fourth highest cohort retention rate in year 5 (64%). However, it is not clear if this drop was an actual drop in the number of teachers that had assignments in general education (most of whom are elementary school teachers), or if there were inconsistencies in the way that elementary school teachers' assignments were classified.
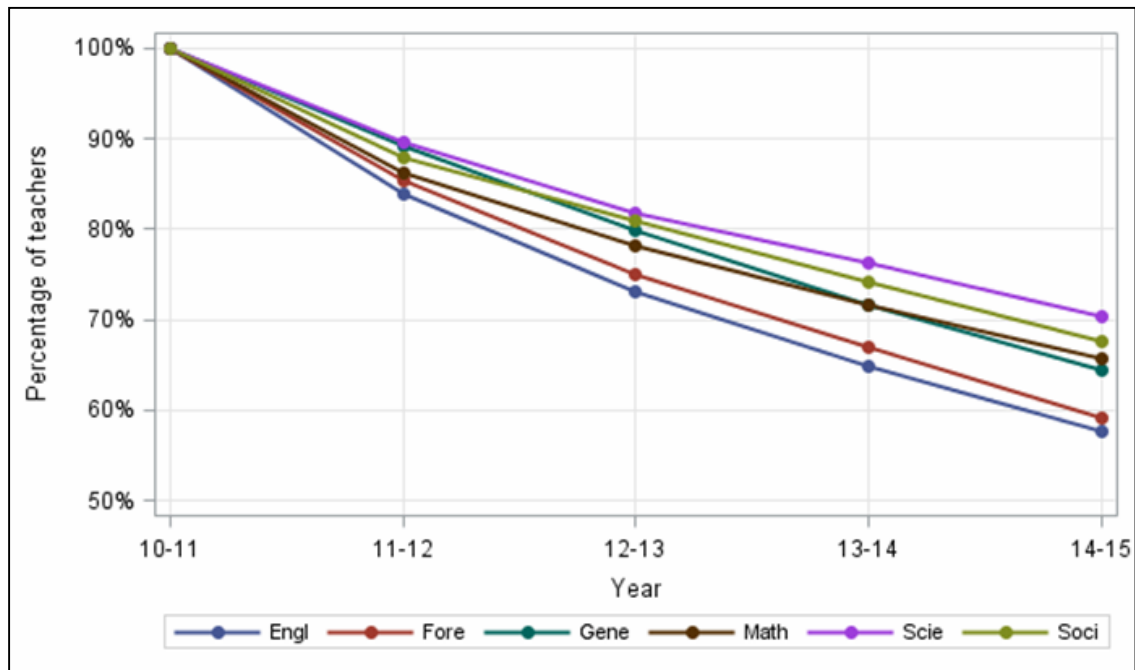
Subject	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Science	100.0%	89.7%	81.9%	76.4%	70.3%
Social studies	100.0%	87.9%	80.9%	74.1%	67.5%
Math	100.0%	86.3%	78.3%	71.5%	65.6%
General education	100.0%	89.1%	79.9%	71.6%	64.4%
Foreign language	100.0%	85.3%	75.1%	67.0%	59.2%
English	100.0%	83.9%	73.0%	64.9%	57.6%

Figure 13. Cohort retention by subject - percentage

Figure 14 shows the number of teachers that had an assignment in each subject. Every year, general education had the highest number of teachers (most of whom are elementary school teachers), followed by English, math, social studies, science, and foreign language.
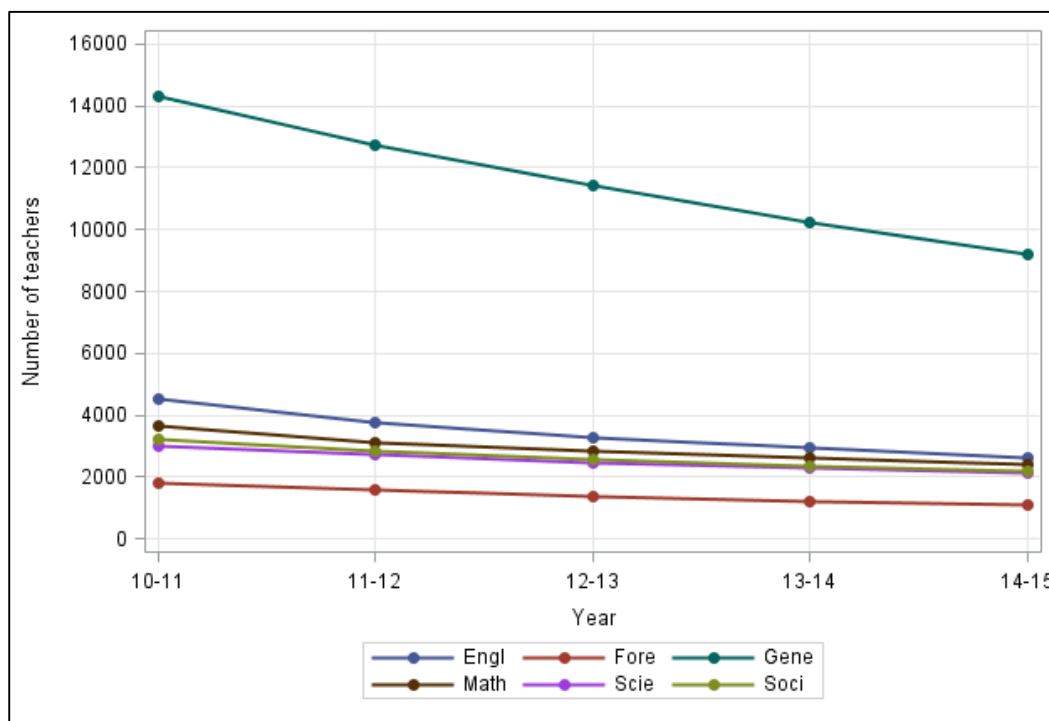
Subject	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Science	3,023	2,710	2,475	2,308	2,126
Social science	3,204	2,816	2,591	2,375	2,163
Math	3,637	3,139	2,846	2,602	2,387
General	14,291	12,736	11,415	10,238	9,203
Foreign language	1,832	1,563	1,375	1,227	1,084
English	4,509	3,781	3,293	2,924	2,597
TOTAL	30,496	26,745	23,995	21,674	19,560

Figure 14. Cohort retention by subject - number of teachers

Cohort retention by grade level

In this analysis, teachers who taught in a given grade level in the base year (2010-2011 academic year) were considered to be in a grade level cohort. Thus, there is a cohort of elementary school teachers (grades 1 to 6) and a cohort of secondary school teachers (grade 7 to 12).[4] If a

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[4] It was not possible to break down secondary school teachers into middle school and high school teachers, because

teacher had assignments in both elementary school and secondary school in the base year, the teacher was included in both cohorts.

The retention rate is defined as the percentage of teachers in a given grade level cohort (which was created in the base year) that still had an assignment in the grade level, regardless of a change in the school, grade, subject, or full-time equivalency of the assignment. Once a teacher was counted as a leaver in one year, the teacher continued to be counted as a leaver in all subsequent years. The following two formulae were used to compute the retention of Minnesota public school teachers by grade level.

$$(1) \quad \frac{\textit{Number of MN public schools teachers who taught in elementary school continuously from the base year to year}_i}{\textit{Number of elementary public school teachers in MN in the base year}}$$

$$(2) \quad \frac{\textit{Number of MN public schools teachers who taught in secondary school continuously from the base year to year}_i}{\textit{Number of secondary public school teachers in MN in the base year}}$$

Figure 15 shows the retention rate of each grade level cohort for 4 years following the base year. Every year, the retention rate of secondary school teachers (69% in year 5) was higher than the retention rate of elementary school teachers (66% in year 5).

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of the way teachers were classified in the raw dataset.
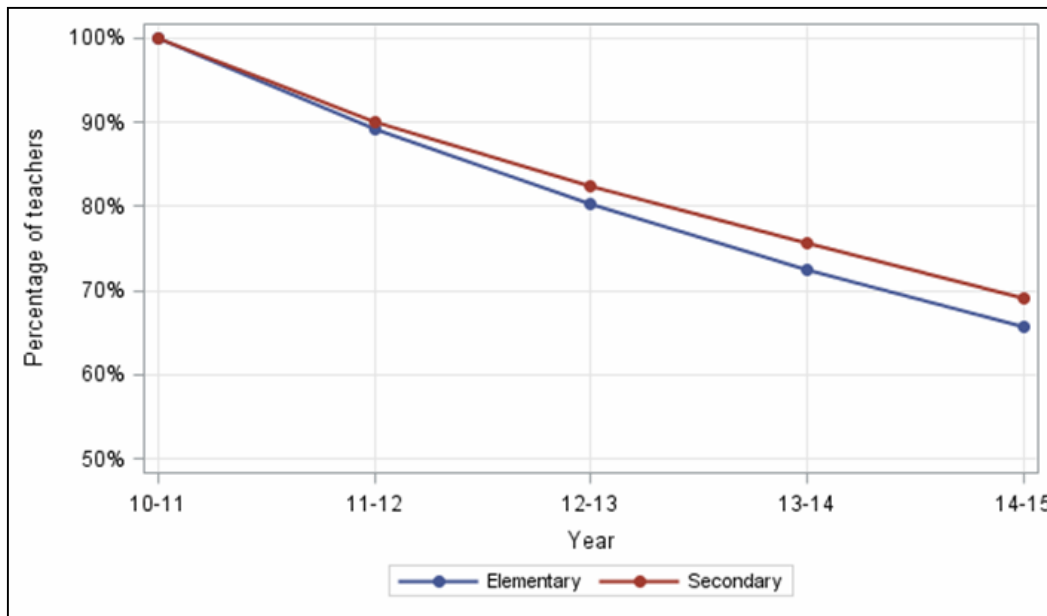
Grade Level	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Secondary school	100.0%	90.1%	82.4%	75.6%	69.2%
Elementary school	100.0%	89.2%	80.3%	72.6%	65.6%

Figure 15. Cohort retention by grade level - percentage

Figure 16 shows the number of teachers that had an assignment in each grade level. Every year, there were more elementary school teachers than secondary school teachers, although the number of elementary school teachers decreased at a faster rate.
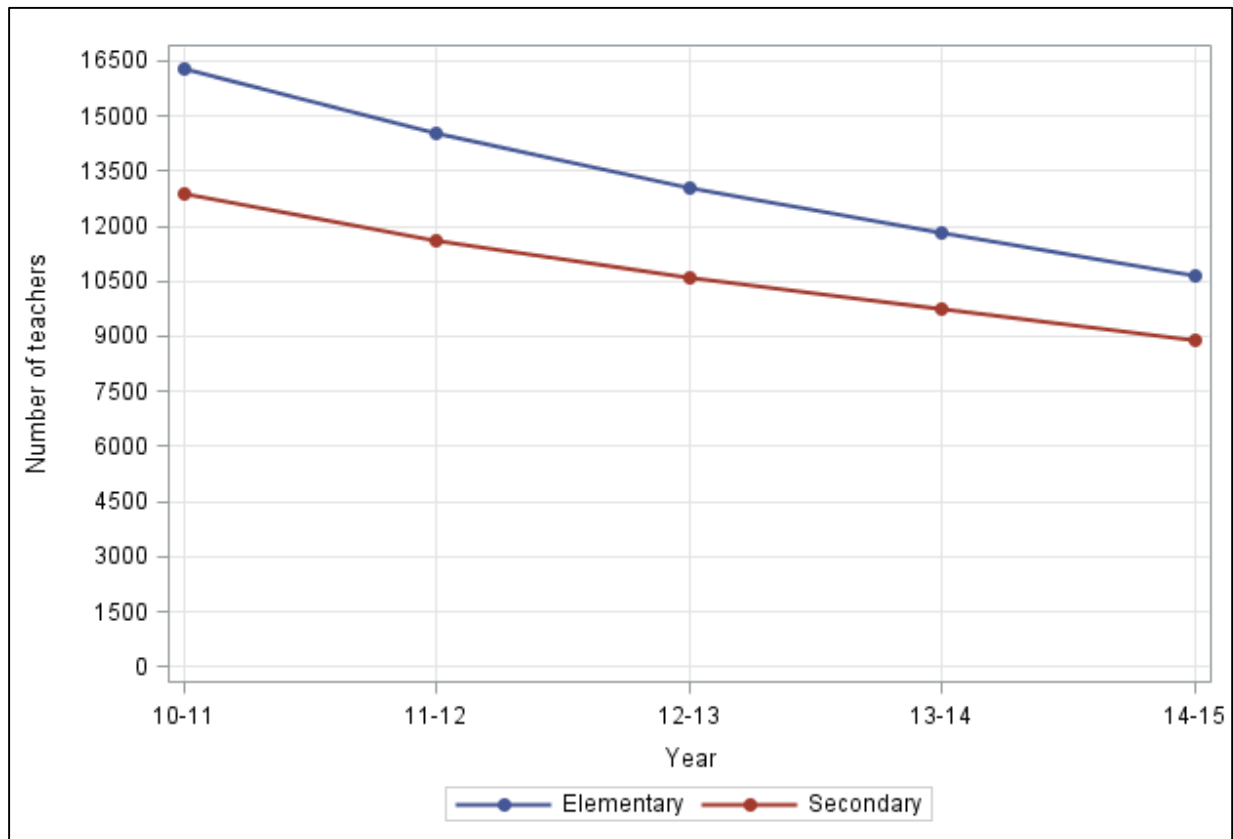
Grade Level	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Secondary school	12,883	11,605	10,609	9,735	8,911
Elementary school	16,266	14,501	13,058	11,806	10,671
TOTAL	29,149	26,106	23,667	21,541	19,582

Figure 16. Cohort retention by grade level - number of teachers

Cohort retention in the five largest districts

In this analysis, teachers who taught in one of the five largest school districts of Minnesota in the base year (2010-2011 academic year) were considered to be in a district cohort. Thus, there is a cohort of teachers from the Minneapolis School District, a cohort of teachers from the St. Paul School District, a cohort of teachers from the Anoka-Hennepin School District, a cohort of teachers from the Rosemount-Apple Valley-Eagan School District, and a cohort of teachers from the Osseo

District School District. If a teacher had assignments in more than one of these school districts, the teacher was included in each of the district cohorts.

These five school districts are within the Seven County Metro where 60% of Minnesota's population is concentrated. They are also the most populated districts among the approximately 500 school districts in Minnesota. All of the five districts are categorized as high-need by the Minnesota Department of Education.[5] Table 3 shows some information about each of these districts. It should be noted that the starting salary for teachers in these districts is relatively low compared to national data or the suggested amount from other research, which is over $40,000.

Table 3. Five largest school districts in Minnesota

School District	Total Population (2010)	Median household income (2009-2010)	Starting teacher salary	County	High need (2009)
Minneapolis	382,583	$ 45,625	$41,292	Hennepin County	Yes
St. Paul	285,068	$ 46,026	$43,021	Ramsey County	Yes
Anoka-Hennepin	226,412	$ 71,919	$39,233	Anoka county	Yes
Rosemount-Apple Valley-Eagan	143,932	$ 82,638	$37,324	Dakota County	Yes
Osseo	135,140	$ 74,682	$ 39,935	Hennepin County	Yes

Source 1: Minnesota Department of Education (2010). 2010 Census. Retrieved from http://w20.education.state.mn.us/MDEAnalytics/Data.jsp
Source 2: Minnesota School District Demographic Profiles. Retrieved from http://proximityone.com/mn_sdc.htm
Source 3: National Council of Teacher quality. Retrieved from http://www.nctq.org/districtPolicy/contractDatabase/district.do?id=252
Source 4: Rosemount-Apple Valley-Eagan School District. Retrieved from http://www.district196.org/
Source 5: Osseo school district. Retrieved from http://www.district279.org/
Note: We could not find aggregated data regarding teacher salary, so we investigated the data

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[5] High-need schools are defined in section 201 of the Higher Education Act of 1965 (20 U.S.C. 1021) as K1-12 schools located in areas where 1) a high percentage of individuals are from families with incomes below the poverty line, 2) a high percentage of school teachers are not teaching in subject areas in which they were trained to teach, and 3) there is a high turnover rate.

presented from the teachers' union (Minneapolis, St. Paul, and Anoka-Hennepin) and from the district (Rosemount Apple Valley-Eagan and Osseo).

The retention rate is defined as the percentage of teachers in a given district cohort (which was created in the base year) that still had an assignment in the school district, regardless of a change in the school, grade, subject, or full-time equivalency of the assignment. Once a teacher was counted as a *leaver* in one year, the teacher continued to be counted as a *leaver* in all subsequent years. The following five formulae were used to compute the retention rate of each district cohort.

(1) $$\frac{\textit{Number of public school teachers who taught in the Minneapolis School District continuously from the base year to year}_i}{\textit{Number of teachers in the Minneapolis School District in the base year}}$$

(2) $$\frac{\textit{Number of public school teachers who taught in the St. Paul School District ontinuously from the base year to year}_i}{\textit{Number of teachers in the St. Paul School District in the base year}}$$

(3) $$\frac{\textit{Number of public school teachers who taught in the Anoka} - \textit{Hennepin School District continuously from the base year to year}_i}{\textit{Number of teachers in the Anoka} - \textit{Hennepin School District in the base year}}$$

(4) $$\frac{\textit{Number of public school teachers who taught in the Rosemount} - \textit{Apple Valley} - \textit{Eagan School District continuously from the base year to year}_i}{\textit{Number of teachers in the Rosemount} - \textit{Apple Valley} - \textit{Eagan School District in the base year}}$$

(5) $$\frac{\textit{Number of public school teachers who taught in the Osseo District School District continuously from the base year to year}_i}{\textit{Number of teachers in the Osseo District School District in the base year}}$$

Figure 17 shows the retention rate of each district cohort for 4 years following the base year. In year 5, Rosemount-Apple Valley-Eagan School District had the highest retention rate (73%), followed by Osseo School District (67%), Anoka-Hennepin School District (66%), St. Paul School District (62%), and Minneapolis School District (56%).

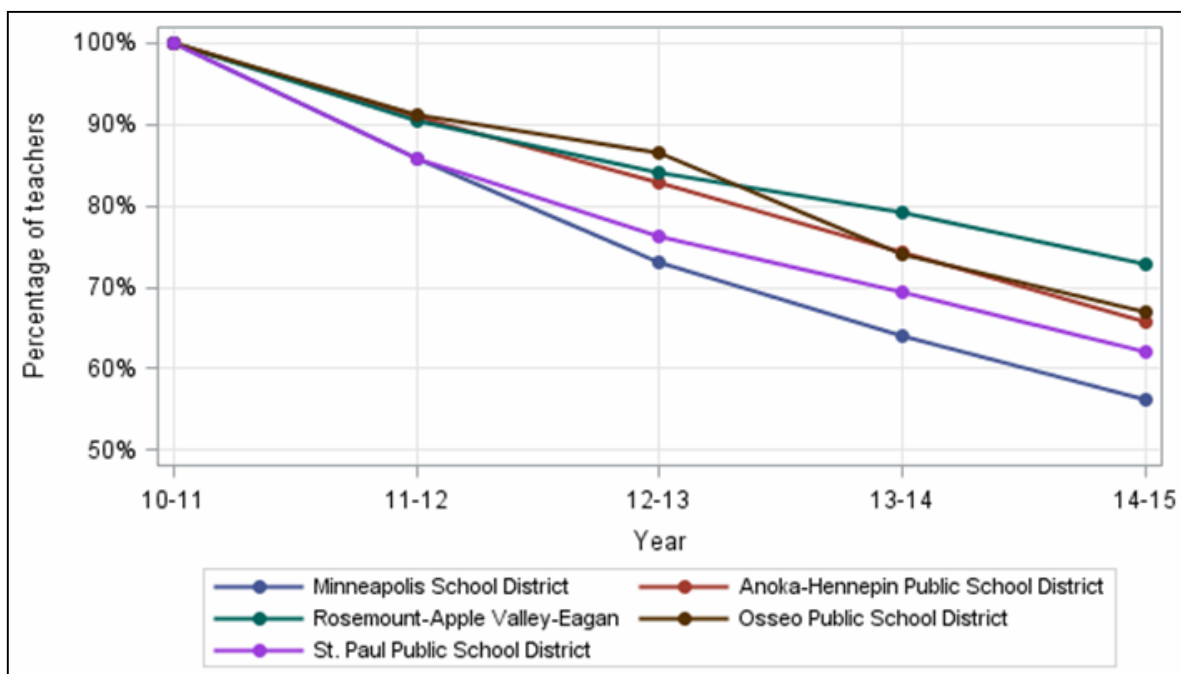| School District	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Rosemount-Apple Valley-Eagan	100.0%	90.5%	84.0%	79.1%	72.9%
Osseo	100.0%	91.3%	86.6%	74.1%	66.9%
Anoka-Hennepin	100.0%	91.0%	82.8%	74.3%	65.8%
St. Paul	100.0%	85.7%	76.2%	69.4%	62.1%
Minneapolis	100.0%	85.8%	73.0%	64.0%	56.2%

Figure 17. Cohort retention in the five largest districts – percentage

Figure 18 shows the number of teachers that had an assignment in each of the five largest school districts. Minneapolis School District had the highest number of teachers in the base year, but dropped to 3rd place in year 5. St. Paul School District had the 2nd highest number of teachers in the base year, and it still had the 2nd highest number of teachers in year 5. Anoka-Hennepin School District had the 3rd highest number of teachers in the base year, but it became the school district with the highest number of teachers in year 5. Rosemount-Apple Valley-Eagan School District had the 4th highest number of teachers in all 5 years, while Osseo School District had the

lowest number of teachers in all 5 years.

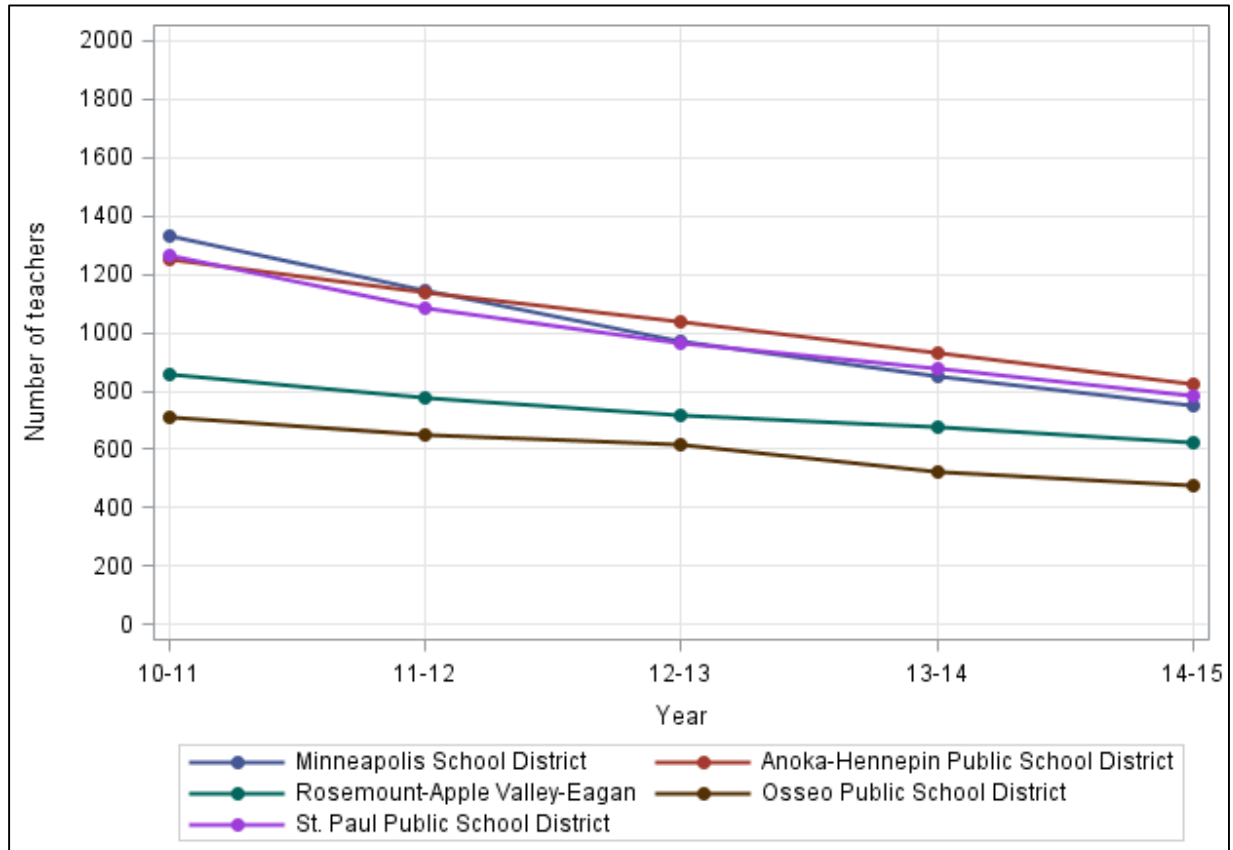| School District	2010-11 (Year 1)	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
Rosemount-Apple Valley-Eagan	855	774	718	676	623
Osseo	709	647	614	525	474
Anoka-Hennepin	1,250	1,137	1,035	929	822
St. Paul	1,265	1,084	964	878	786
Minneapolis	1,330	1,141	971	851	747
TOTAL	5,409	4,783	4,302	3,859	3,452

Figure 18. Cohort retention in the five largest districts - number of teachers

IX. CHURN ANALYSIS

Figure 19 shows the level of churn at the school, subject, district, and grade level. Churn

is different from retention in that it counts the number of newcomers and leavers in the numerator, and the number of teachers in the preceding year in the denominator. The formulas for calculating churn at each level of analysis are presented below (Boruch, 2016). It should be noted that only teachers in the full-wide file (used for the retention analysis) were included in this analysis.

Churn within the school

Ratio of newcomers plus leavers in year t divided by the number of teachers in the preceding year, for each school and each year covered in the analysis.

$$\frac{New\ comers\ in\ school_t + Leavers\ in\ school_t}{Number\ of\ teachers\ in\ school_{t-1}}$$

Churn within the subject

Ratio of newcomers plus leavers in year t divided by the number of teachers in the preceding year, for each subject and each year covered in the analysis.

$$\frac{New\ comers\ in\ subject_t + Leavers\ in\ subject_t}{Number\ of\ teachers\ in\ subject_{t-1}}$$

Churn within the district

Ratio of newcomers plus leavers in year t divided by number of teachers in the preceding year, in each district and for each year covered in the analysis.
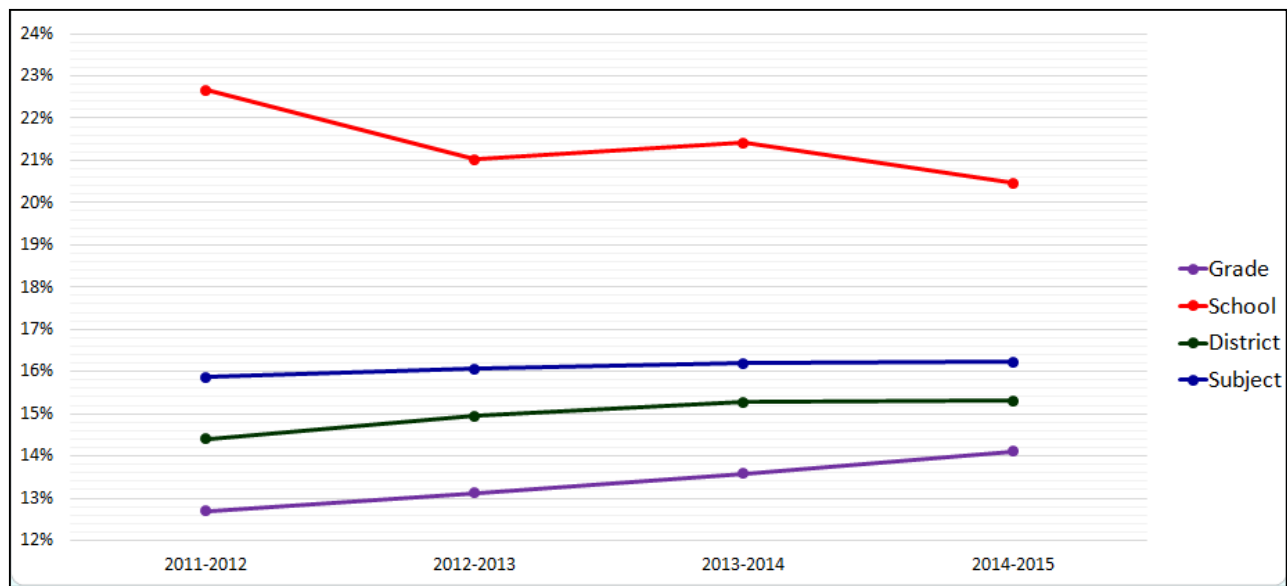
$$\frac{New\ comers\ in\ district_t + Leavers\ in\ district_t}{Number\ of\ teachers\ in\ district\ _{t-1}}$$

Churn within the grade

Ratio of newcomers plus leavers in year t divided by the number of teachers in the preceding year, for each grade and each year covered in the analysis.

$$\frac{New\ comers\ in\ grade_t + Leavers\ in\ grade_t}{Number\ of\ teachers\ in\ grade_{t-1}}$$

Level of churn	2011-12 (Year 2)	2012-13 (Year 3)	2013-14 (Year 4)	2014-15 (Year 5)
School	22.7%	21.0%	21.4%	20.5%
Subject	15.9%	16.1%	16.2%	16.2%
District	14.4%	15.0%	15.3%	15.3%
Grade	12.7%	13.1%	13.6%	14.1%

Figure 19. Churn - at different levels

X. CONCLUSION AND NEXT STEPS

The following conclusions can be drawn from this paper:

1) As expected, the retention rate was the highest at the state level (69.7% in year 5), followed by the district level (64.9% in year 5), and then the school level (58.4% in year 5). This is because a teacher who moves to a different school but remains in the same district is counted as a leaver at the school level, but counted as a stayer at the district and state levels; a teacher who moves to a different district is counted as a leaver at the school and district levels, but is counted as a stayer at the state level; and a teacher who no longer teaches in Minnesota is counted as a leaver at the school, district, and state levels. This also explains why the churn rate was the highest

at the school level, followed by the district level.

2) The retention rate among math and science teachers (65.6% and 70.3% in year 5, respectively) was higher than the retention rate among English and foreign language teachers (57.6% and 59.2% in year 5, respectively). This is contrary to the literature that the retention rate is low among math and science teachers.

3) The retention rate among elementary school teachers (65.6% in year 5) is lower than the retention rate among secondary school teachers (69.2% in year 5). This is in line with findings from API reports from other states, such as New Jersey (Ye et al., 2016).

4) The churn rate was relatively stable over 5 years at the grade level (ranging from 12.7% to 14.1%), the district level (ranging from 14.4% to 15.3%), the subject level (ranging from 15.9% to 16.2%), and the school level (ranging from 20.5% to 22.7%).

Our next steps will focus, primarily, on the analysis of churn. Specifically, we hope to take a closer look at churn by main district, churn by subject, and churn by grade level.

Moreover, Minnesota's Department of Education has published new data on education staff for 2015. Data is also available for some previous years. Depending on how complete the information is, we may consider expanding our analyses to examine longer-term trends in teacher retention and churn.

We also hope to conduct some exploratory analyses. For example, we would like to examine whether our retention estimates would change if we tracked the teachers who taught at more than one school or who taught part-time in the base year. Indeed, it might be that a teacher was teaching part-time in the base-year and thus excluded from the retention analysis and labelled as a "new comer" in the churn analysis. Also, it would be interesting to compare average teacher tenure (i.e., the length of time a person works as a teacher) to state-level churn and retention.

Retention and churn estimates depend on the overall number of teachers (be it in the base or previous year), whereas average teacher tenure is an estimate that is not contingent on the overall number of teachers.

Finally, we would like to assess whether certain variables moderate the results, such as low-poverty versus high-poverty, rural versus urban, and public versus charter school status, as well as teacher age and experience. Also, we would like to examine whether average teacher salary correlates with teacher retention. Furthermore, if we can locate data on student performance per district or school, it would be insightful to assess whether higher teacher retention correlates with higher student performance.

Acknowledgements

APPENDIX 1 - Detailed subjects included in each core subject

English	Foreign language	General	Math	Science	Social studies
− Advanced Placement English	− American Sign Language	− Bilingual Elementary Education	− 7th Grade Math	− Advanced Physics	− American Indian History, Language & Culture
− Composition	− Chinese	− General Elementary Education	− 8th Grade Math	− Aeronautics/ Aviation	− Anthropology/ Archeology
− Comprehensive Language Arts	− Chinese, AP		− Advanced Algebra/ Integrated Math III	− Astronomy	− AP/IB Social Studies
− Creative Writing	− English As Second Language		− Algebra/Integrated Math I	− Bilingual Science	− Economics
− Dramatic Literature (Communication Arts)	− Exploratory Language/Culture Program		− AP/IB Calculus	− Biology - AP/IB	− Elementary Social Studies
− Elementary Reading	− French		− Basic Mathematics	− Biology Special Topics	− Geography
− International Baccalaureate English	− French - Advanced Placement		− Bilingual Math	− Chemistry - AP/IB	− History
− Journalism	− German		− Calculus	− Chemistry Special Topics	− Humanities
− Literature	− German - Advanced Placement		− Elementary Math	− Earth Science	− Integrated Social Studies
− Secondary Reading	− Japanese		− General Or Consumer Math	− Elementary Science	− Philosophy
			− Geometry/ Integrated Math II	− Environmental Science	
			− Other Math Classes	− General Biology	

− Technical Writing	− Latin
	
	− Ojibwe
	
	− Other Languages Not
	
	  Listed
	
	− Russian
	
	− Spanish
	
	− Spanish - Advanced
	
	  Placement
			− Pre-Algebra
			
			− Pre-Calculus/
			
			  Integrated Math IV
			
			− Probability &
			
			  Statistics/ Discrete
			
			  Math
				− General Chemistry
				
				− General Physics
				
				− Integrated Science
				
				− Life Science
				
				− Physical Science
				
				− Physics - AP/IB
				
				− Second Level
				
				  Biology
					− Political Science
					
					  (Civics, Amer. Govt.)
					
					− Psychology
					
					− Sociology

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