Do the Most Effective Math and Science Teachers Leave?:
Evidence on Turnover among Middle School Teachers in a Large Urban District

Teacher turnover has been identified as a significant challenge for urban school districts (Ingersoll, 2004). In some districts, about half of the newly-hired teachers leave within three years (Neild, Useem, Travers, & Lesnick, 2003). It is widely understood that some turnover in urban school districts is healthy, particularly if that turnover is concentrated among individuals who are the least effective with students. On the other hand, if the "drain" among urban teachers is most severe among its highest performers, then the consequences of urban teacher turnover for students would be even more severe than heretofore realized. In this paper, we examine whether turnover is more common among teachers who are more effective with their students, as measured by "value-added" achievement on standardized tests.

Previous research has related academic characteristics of teachers (such as their GPA, college major, licensing exam scores, or type of college attended) to the likelihood of leaving one's school, district, or the profession altogether. In New York State, for example, teachers with higher licensing exam scores and/or attended more selective undergraduate colleges are more likely to transfer to another district or to leave the state's public schools entirely (Lankford, Loeb, & Wyckoff, 2002). A recent study from Illinois found similar results: teachers with higher ACT scores and those who attended selective colleges were more likely to leave the profession or to transfer to another school (De Angelis & Presley, 2007). It seems like common sense to infer that teachers with higher exam scores and stronger academic backgrounds would "produce" the greatest student achievement, since there is a known association between a stronger content background and student learning (see, for example, Rowan, Chaing, & Miller, 1997). However, researchers recognize that exam scores and college selectivity are only weak proxies for instructional quality, and any student will affirm that there is more to being a good teacher than having a strong content background.

Whether teachers who produce the greatest achievement are more likely to a) leave their district or b) transfer to another school in their district is a question in need of specific empirical support. In reviewing the literature, we found only a few studies that examined whether teachers with the greatest value-added contribution to their students' learning were more likely to leave. Hanushek, Kain, O'Brien, and Rivkin (2005) found that, as a group, teachers who left a large urban district in Texas were no better at producing achievement than those who stayed. Likewise, using data for the entire state of North Carolina, Goldhaber, Gross, and Player (2007) find that teachers who produce the greatest achievement are more likely to remain in their schools.

In this paper, we add to the research base about whether the most effective teachers leave their districts or transfer schools within districts, employing a merged teacher-student data set from a large urban district. Using a multilevel model, we look specifically at whether middle school math and science teachers who added the most value (in terms of fall to spring academic growth, measured by standardized tests) were more likely to leave the district or to transfer to another school in the district.

Data and Methods

We use a unique data set created from the administrative records of a large urban district. From files containing individual-level student information, we obtained data on gender, race or ethnicity, attendance rate, scores on the mathematics and science sections of the CTBS Terra Nova standardized test, grade, the specific courses taken during a given year, and the teacher for each courses. Files containing individual-level teacher information include data on teachers' certification(s), age, gender, race or ethnicity, and years of experience in the district. Student files cover the school year 2002-2003. The teacher data files cover the 2002-2003 school year as well as the preceding school year (2001-2002) and three subsequent years (2003-2004 through 2005-2006). Teacher data from the preceding and subsequent years are used to determine a) whether a teacher is new to the district during the target year (2002-2003) and b) whether the teacher left the district or transferred to another school during the subsequent three years (that is, by 2005-2006).

During the 2002-2003 school year, students in the district were given the CTBS Terra Nova test during the fall and again during the spring. These two administrations of the exam at the beginning and end of the school year allow us to assess the student-level, teacher-level, and school-level correlates of making larger or smaller learning gains during a single year.

The analysis proceeds in two major steps. In our **first step**, we create a variable estimating the "value added" by the teacher during the 2002-2003 school year, net of key student and school characteristics (described below). Specifically, using a method described by Raudenbush and Willms (1995), we estimate the residual from a model with spring achievement as the dependent variable. We control for a number of factors that represent the level of classroom or workplace challenge that teachers encounter. We estimated the residual in a number of different ways. In the end, we selected the residual from the equation below because it made the most conceptual sense, but in fact the teachers who were in the tails of the distribution tended to stay in the tails no matter which model we used. Using an HLM model, our equations predicting spring test score in math and science respectively are:

Level 1 (student level)

$$Y_{ijk} = \beta_{0jk} + \beta_{1jk}(Grade\ 5)_{ijk} + \beta_{2jk}(Grade\ 6)_{ijk} + \beta_{3jk}(Grade\ 7)_{ijk} + \beta_{4jk}(Male)_{ijk} + \beta_{5jk}(Special\ Education)_{ijk} + \beta_{6jk}(English\text{-}Language\text{-}Learner)_{ijk} + \beta_{7jk}(African\ American)_{ijk} + \beta_{8jk}(Asian)_{ijk} + \beta_{9jk}(Latino)_{ijk} + \beta_{10jk}(Other\ ethnicity)_{ijk} + \beta_{11jk}(Number\ of\ courses)_{ijk} + \beta_{12jk}(Attendance)_{ijk} + \beta_{13jk}(Fall\ Test\ Score)_{ijk} + r_{ijk}$$

Level 2 (teacher level)

$$\beta_{0jk} = \gamma_{00k} + \gamma_{01k}(Number\ of\ courses\ taught\ in\ the\ target\ subject)_{jk} + u_{0k}$$

Level 3 (school level)

$$\gamma_{00k} = \alpha_{000} + \alpha_{001}(Low\ Income) + u_{00k}$$

From this model, we obtained the residual (the difference between the actual and expected score). The residual is our indicator of the "value added" by the teacher. About 22,000 students are represented in this model.

Consistent with Hanushek et al. (2005), we find that almost all of the variation in the residual (98%) is within schools rather than between them. Further, descriptive analyses indicate that teachers who have larger residuals are more likely to stay in the district. In Table 1 below, we break down the residuals *for math teachers* into quartiles and indicate the percentage of teachers in each category who remain in the district for 3 years. There is a twenty percentage point difference in the district retention rates of teachers with residuals in the top quartile, in comparison to those with bottom quartile residuals.

Table 1: Percentage of Teachers Remaining in the District, by Residual Quartile

	Lowest 25%	2nd quartile	3rd quartile	Highest 25%
Left district	43.5%	40.5%	35.1%	23.1%
Remained in district	56.5%	59.5%	64.9%	76.9%
Total (n)	100% (131)	100% (131)	100% (131)	100% (130)

However, we see no such pattern with regard to whether the teacher remains in his or her school or transfers to another school in the district. Table 2 presents the percentage of teachers remaining in the school, by residual quartile.

Table 2: Percentage of Teachers Remaining in the School, by Residual Quartile

	Lowest 25%	2nd quartile	3rd quartile	Highest 25%
Transferred to another school	9.5%	15.7%	14.8%	10.6%
Remained in school	90.5%	84.4%	85.3%	89.4%
Total (n)	100% (116)	100% (115)	100% (122)	100% (123)

In our **second major step**, we created three multilevel models to assess whether these relationships persist when we control for other variables associated with producing student achievement (e.g. teacher certification and experience) and remaining in a district or school (e.g. age, gender, and school characteristics). The three models, respectively, predict whether the teacher 1) remained in the district for an additional year (though not necessarily at the same school); 2) remained in the district for an additional 3 years; or 3) remained in the district for the next year, but transferred to another school. For Models 1 and 2, the dependent variable is a dummy variable with 1 equal to staying in the district for the specified period of time. For Model 3, the dependent variable is a dummy with 0 equal to "remained in the district but transferred schools" and 1 equal to "remained at the same school." Therefore, individuals who left the district entirely are removed from Model 3. These are two-level models with teachers nested within schools. For brevity, in Table 3 we present only the models for math teachers, although we have also run models for science teachers and will include them in the full paper.

The independent variables include dummies for teacher race/ethnicity. There are so few Asian or Native American teachers (n=8) that we had trouble running our models with these indicators; we therefore dropped them from the analysis. Models also include: teacher age, age squared, whether the teacher was fully certified to teach in any subject (not necessarily the subject that he or she was teaching), whether the teacher was new to the district (a proxy for experience), and our "teacher effect" variable. At the school level, we control for percent of students who are low income. There are 523 teachers and 37 schools in these models.

Table 3

Mathematics Models

	Predicting teacher stays in district next year		*Predicting teacher stays in district for at least 3 years*		*Predicting teacher stays in same school next year, if staying in district*	
	Odds ratio	Sig.	Odds ratio	Sig.	Odds ratio	Sig.
Intercept	5.837	*	1.350		23.590	***
Teacher Level						
Demographic variables						
African American	2.283	*	1.406		0.994	
Hispanic	4.127		2.032	(.078)	0.707	
Male	1.643		1.513	*	1.389	
Age	1.017		1.402	***	0.992	
Age squared			0.996	***		
Teaching variables						
Certified to teach	5.402	***	3.255	***	0.512	
New to district	1.056		0.499	*	0.705	
Residual ("teacher effect")	1.089	*	1.078	**	1.010	
School variables						
80-89% poverty	0.350		0.406	*	0.570	
>90% poverty	0.280	(.067)	0.365	**	0.388	*

*p<.05 **p<.01 *p<.001

In Model 1 (predicting the odds of remaining in the district, though not necessarily at the same school), we find that just three of our variables are significant predictors: being African American, being fully certified to teach, and the "teacher effect" variable. Of particular note is that teachers who produce greater achievement among their students have *higher odds* of remaining in the district. This effect is also seen in Model 2. In Model 2, we observe that older teachers are more likely to remain in the district, although it is a nonlinear effect as shown by the significance of the age-squared variable. In addition, male teachers have higher odds of remaining in the district, as do those who are certified to teach. Parallelling national trends in new teacher turnover, teachers who were new to the district three years earlier have odds of staying that are half of those who were not new. Finally, at the school level, teachers at schools with higher percentages of low income students have lower odds of remaining in the district for three years.

In contrast, we find that there is no impact of a teacher's "value added" on the odds of transferring to another school within the same district (as opposed to remaining at the same school). However, we do see that teachers who are at schools with the very highest percentages of low-income students (>90%) have reduced odds of remaining at their school. This outcome makes sense, given that a) intra-district transfer policies take into account a teacher's seniority rather than that ability to "produce" achievement, and b) we know from other research that the typical transfer pattern is for teacher to leave schools with higher percentages of low-income students to schools with lower percentages of these students.

Discussion

We learn several important things in our paper. First, consistent with work by Hanushek et al (2005), we find that, as a group, the teachers who remain in the district are better at producing student achievement than those who leave. At the same time, the descriptive data show us that the district is losing more of its highest-performing teachers than it can afford to lose (a loss of 25% over three years), and retaining too many of its lowest-performing teachers (50% over three years). The paper concludes with a discussion of the ramifications of this research for educational policy.

References

DeAngelis, K., & Preston, J. (2007). *Leaving schools or leaving the profession: Setting Illinois' record straight on new teacher attrition.* Policy research report IERC 2007-1. Edwardsville, IL: Illinois Education Research Council.

Goldhaber, D., Gross, B., & Player, D. (2007, March). Are public schools really losing their "best"?: Assessing the career transitions of teachers and their implications for the quality of the teacher workforce. Paper presented at the Annual Conference of the American Education Finance Association, Baltimore, MD.

Hanushek, E., Kain, J., O'Brien, D. & Rivkin, S. (2005). The market for teacher quality. National Bureau of Economic Research, Working Paper No. 11154.

Ingersoll, Richard. (2004). Why do high-poverty schools have difficulty staffing their classrooms with qualified teachers? Washington: Center for American Progress.

Lankford, H., Loeb, S., & Wyckoff, J. (2002). Teacher sorting and the plight of urban schools: A descriptive analysis. *Educational evaluation and policy analysis, 24*(1), 37-62.

Neild, R., Useem, E., Travers, E. & Lesnick, J. (2003). *Once and for all: Placing a highly qualified teacher in every Philadelphia classroom*. Philadelphia: Research for Action.

Raudenbush, S., & Willms, J. (1995). The estimation of school effects. *Journal of educational and behavioural statistics*, *20*(4), 307-355.

Rowan, B., Chiang, F.S., & Miller, R. J. (1997). Using research on employee's performance to study the effects of teachers on students' achievement. *Sociology of education*, *70,* 256-284.