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Understanding Supply and Demand Among Mathematics and Science Teachers

Abstract
Few educational problems have received more attention in recent years than the failure to ensure that elementary and secondary classrooms are staffed with qualified teachers. Severe teacher shortages, education researchers and policy makers have told us, are confronting our elementary and secondary schools. At the root of these problems, we are told, is a dramatic increase in the demand for new teachers resulting primarily from two converging demographic trends - increasing student enrollments and increasing teacher turnover due to a graying teaching force. Shortfalls of teachers, the argument continues, are forcing many school systems to resort to lowering standards to fill teaching openings, inevitably resulting in high levels of underqualified teachers and lower school performance.

Comments

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few educational problems have received more attention in recent years than the failure to ensure that elementary and secondary classrooms are staffed with qualified teachers. Severe teacher shortages, education researchers and policy makers have told us, are confronting our elementary and secondary schools. At the root of these problems, we are told, is a dramatic increase in the demand for new teachers resulting primarily from two converging demographic trends—increasing student enrollments and increasing teacher turnover due to a graying teaching force. Shortfalls of teachers, the argument continues, are forcing many school systems to resort to lowering standards to fill teaching openings, inevitably resulting in high levels of underqualified teachers and lower school performance (NCEE 1983; NAS 1987; NCTAF 1997).

These researchers and policy analysts have also stressed that shortages will affect some teaching fields more than others. Special education, mathematics, and science, in particular, have usually been targeted as fields with especially high turnover and those predicted most likely to suffer shortages (Murnane et al. 1991; Boe et al. 1997; Grissmer and Kirby 1992, 1997; Weiss and Boyd 1990). As a result, over the past decade, the inability of schools to adequately staff classrooms with qualified teachers (hereafter, school staffing problems) has increasingly been recognized as a major social
problem, has received widespread coverage in the national media, and has been the target of a growing number of reform and policy initiatives.

The prevailing policy response to these school staffing problems has been to attempt to increase the quantity of teacher supply. In recent years a wide range of initiatives have been implemented to recruit new candidates into teaching. Among these are career-change programs, such as troops-to-teachers, designed to entice professionals into midcareer switches to teaching and Peace Corps-like programs, such as Teach for America, designed to lure the best and brightest into understaffed schools. Many states have instituted alternative certification programs, whereby college graduates can postpone formal education training and begin teaching immediately. Financial incentives, such as signing bonuses, student loan forgiveness, housing assistance, and tuition reimbursement have all been instituted to aid recruitment (for a review of these initiatives, see Hirsch et al. 2001). The federal No Child Left Behind Act of 2001 (2002) provides extensive funding for such initiatives.

Concern over school staffing problems has also given impetus to empirical research on teacher shortages and turnover. However, as numerous analysts have noted, it was difficult, initially, to study these issues because of a lack of accurate data, especially at a nationally representative level, on many of the pertinent issues surrounding teacher supply, demand, and quality. In order to obtain such data, the National Center for Education Statistics (NCES), the statistical arm of the U.S. Department of Education, designed the Schools and Staffing Survey (SASS) and its supplement, the Teacher Follow-up Survey (TFS), in the late 1980s.

The Project

Over the past decade and a half I have been undertaking research using SASS and TFS to study a number of issues concerned with teacher supply, demand, and quality (for summaries, see Ingersoll 1999, 2001, 2003a). In this chapter I will briefly summarize what the data tell us about the realities of school staffing problems and teacher shortages, especially for mathematics and science teachers. I will argue that the conventional wisdom on teacher shortages is largely a case of a wrong diagnosis and a wrong prescription and that while the above policy efforts are often worthwhile, the data show they will not solve the teacher staffing problems schools are facing.

SASS and TFS are the largest and most comprehensive data source avail-
SASS administers survey questionnaires to a random sample of about 50,000 teachers from all types of schools and from all 50 states. NCES has administered SASS on a regular basis; to date, four cycles have been completed—1987–88, 1990–91, 1993–94, and 1999–2000. In addition, all those teachers who leave their teaching jobs in the year subsequent to the administration of the initial survey questionnaire are again contacted to obtain information on their departures. This supplemental study—the TFS—is the largest and most comprehensive data source on teacher turnover in the U.S. (For information on the TFS see Chandler et al. 2004.)

The data presented here come primarily from the two most recent cycles of the TFS (1994–95 and 2000–01) and represent all teachers for grades K–12 and from all types of schools, both public and private. Mathematics and science teachers, the primary focus of this chapter, are those identified by their principals as having their main teaching assignment in either mathematics or science. They represent about 11 percent of the total teaching force. About 22 percent of these mathematics and science teachers are employed in elementary or middle schools, another 73 percent are in secondary schools, and about 5 percent are in combined (K–12 grades) schools. Throughout, I will compare the data on mathematics/science teachers with the data for all teachers.

Schools have two types of teacher turnover. The first, often called teacher attrition, refers to those who leave the occupation of teaching altogether. The second type, often called teacher migration, refers to those who transfer or move to different teaching jobs in other schools. Research on teacher supply and demand has often emphasized the first type and neglected the second. Many assume that teacher migration is a less significant form of turnover because it does not increase or decrease the overall supply of teachers, as do retirements and career changes, and, hence, assume it does not contribute to the problem of staffing schools and does not contribute to overall shortages. From a systemic point of view, this is probably correct. However, from the viewpoint of those managing schools, teacher migration and attrition have the same effect—in either case they result in a decrease in staff that usually must be replaced. Hence, from the school’s perspective, teacher migration can, indeed, contribute to the problem of keeping schools staffed with qualified teachers. For this reason, this chapter will...
present data on both teacher migration and teacher attrition. Hereafter, I will refer to teacher migration as *movers*, teacher attrition as *leavers* and total turnover as *departures*.

In the next section I will present data on how many teachers depart from their teaching jobs and establish the importance of teacher turnover for teacher shortages. In the following section I will present statistics on why teachers move from or leave their teaching jobs. These latter data are drawn from items in the TFS questionnaire that asks teachers to indicate from a list provided in the survey questionnaire the most important reasons for their migration or attrition (see appendix). Next, I present the results from a set of questionnaire items that asks those mathematics and science teachers who had departed to suggest things schools could do to encourage teachers to remain in teaching. Then I present data on what difference induction programs make in reducing beginning-teacher turnover. Finally, I conclude by briefly discussing the implications of these findings for understanding and addressing the staffing problems of schools.

**Results: The Importance of Teacher Turnover**

Consistent with shortage predictions, the data show that the demand for teachers has indeed increased. Since 1984, student enrollments have increased, teacher retirements have also increased, most schools have had job openings for teachers, and the size of the elementary and secondary teaching workforce has increased. More important, the SASS data tell us substantial numbers of those schools with teaching openings have experienced difficulties finding qualified candidates to fill their positions. Overall, the data show that for the 1999-2000 school year, 58 percent of all schools reported at least some difficulty filling one or more teaching job openings, in one or more fields. Forty-two percent of secondary schools indicated they had at least some difficulty filling their mathematics openings (see Figure 1).

But the data also show that the demand for new teachers and subsequent staffing difficulties are not primarily due to student enrollment and teacher retirement increases. Most of the demand and hiring is simply to replace those who recently departed from their teaching jobs and, moreover, most of this teacher turnover has little to do with a graying workforce.

Teaching is a relatively large occupation—it represents 4% of the nationwide civilian workforce. There are, for example, more than twice as
Figure 1: Percent secondary schools with difficulties filling their teaching vacancies, by field

<table>
<thead>
<tr>
<th>Field</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>42</td>
</tr>
<tr>
<td>Special Education</td>
<td>34</td>
</tr>
<tr>
<td>Life Science</td>
<td>30</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>29</td>
</tr>
<tr>
<td>Physical Science</td>
<td>27</td>
</tr>
<tr>
<td>English</td>
<td>24</td>
</tr>
<tr>
<td>Music/Art</td>
<td>21</td>
</tr>
<tr>
<td>Social Studies</td>
<td>14</td>
</tr>
<tr>
<td>ESL/ESOL/Bilingual</td>
<td>12</td>
</tr>
</tbody>
</table>

Source: 1999–2000 Schools and Staffing Survey

many K–12 teachers as registered nurses and five times as many teachers as either lawyers or professors (U.S. Bureau of the Census 1998). The TFS data show that teaching has a relatively stable turnover rate: 14.5 percent in 1988–89, 13.2 percent in 1991–92, 14.3 percent in 1994–95, and 15.7 percent in 2000–01. Moreover, total teacher turnover is about evenly split between movers and leavers.

This rate of turnover and the sheer size of the teaching force means that there are large flows in, through, and out of schools each year. For instance, the SASS/TFS data show that about 535,000 teachers (including within-district school-to-school transfers) entered schools just prior to the 1999–2000 school year. But, in the following 12 months even more—about 546,000 teachers—departed their jobs. In other words, in that 12-month period over a million teachers—almost one third of the teaching force—were in job transition. The image that these data suggest is one of a revolving door (see Figure 2).
Figure 2: Numbers of teachers in transition during the 1999-2000 school year

Not in Transition
2,362,239

Departures
546,200

Entrants
534,861

Source: 1999–2000 Schools and Staffing Survey

Of course, not all teacher or employee turnover is detrimental. There is an extensive research literature on employee turnover conducted by those who study organizations and occupations in general (e.g., Price 1977; Mobley 1982). On the one hand, researchers in this tradition have long held that a low level of employee turnover is normal and efficacious in a well-managed organization. Too little turnover of employees is tied to stagnancy in organizations; effective organizations usually both promote and benefit from a limited degree of turnover by eliminating low-caliber performers and bringing in new blood to facilitate innovation. On the other hand, researchers in this tradition have also long held that high levels of employee turnover are both cause and effect of performance problems in organizations (Price 1989).

From this organizational perspective, employee turnover is especially consequential in work sites, like schools, that have production processes requiring extensive interaction among participants (Lortie 1975; Ingersoll 2003b). Such organizations are unusually dependent upon commitment, continuity, and cohesion among employees and, hence, especially vulnerable to employee turnover. From this perspective, high turnover of teachers from schools is of...
concern not simply because it may be an indicator of sites of potential staffing problems, but because of its relationship to school performance. Moreover, from this perspective, high rates of teacher turnover are of concern not only because they may be an indication of underlying problems in how well a school functions, but also because they can be disruptive, in and of themselves, to the quality of school cohesion and performance.

Although the data show that teaching has relatively high turnover, the data also show that the revolving door varies greatly among different kinds of teachers. Notably, the turnover rate for mathematics/science teachers is higher than for teachers in some other fields (see Figure 3). Moreover, as found in previous research (Murnane et al. 1991), the TFS data show that teaching is an occupation that loses many of its newly trained members very early in their careers—long before the retirement years. I used the TFS data to provide a rough estimate of the cumulative attrition of beginning teachers from the occupation in their first several years of teaching. The data suggest that after just five years, between 40 and 50 percent of all beginning teachers have left teaching altogether.

**Figure 3:** Percent annual teacher turnover, by field

![Figure 3: Percent annual teacher turnover, by field](image)

Source: 1994–1995 Schools and Staffing Survey
In short, the demand for new teachers, and the subsequent problems schools face are, to a significant extent, due to teachers moving from or leaving their jobs at higher rates than in many other occupations. These patterns are chronic—similar results are found in all four cycles of the TFS data from the late 1980s to 2001.

These data raise an important question: Why do these teachers depart their jobs?

**Results: The Sources of Teacher Turnover**

This next section turns to the reasons behind teacher turnover, especially among mathematics and science teachers. Figure 4 presents data on the percentage of teachers who reported particular categories of reasons were important for their departures, separately for all teachers and for mathematics/science teachers. As illustrated in Figure 4, overall, mathematics/science teachers do not greatly differ from other teachers in the reasons why they move from or leave their jobs. Contrary to conventional wisdom, retirement is not an especially prominent factor. It accounts for only a moderate part of total turnover. Notably, retirement also does not account for the relatively high rates of turnover by mathematics/science teachers.

School staffing cutbacks, due to layoffs, school closings and reorganizations, account for an even smaller proportion of turnover than does retirement. Staffing actions more often result in migration to other teaching jobs rather than departure from the teaching occupation altogether.

Personal reasons, such as departures for pregnancy, child rearing, health problems and family moves are far more often given as reasons for turnover than are either retirement or staffing actions (38 percent for all teachers and 44 percent for mathematics/science).

Finally, two related reasons are, together, a very prominent source of turnover. More than half of all teachers who left their jobs give as an important reason either job dissatisfaction or the desire to pursue another job, in or out of education. I have found these findings to be true across different cycles of the data. Moreover, I have found similar factors lie behind both teacher migration and teacher attrition.

What are the sources of this dissatisfaction that lead to turnover and what can schools do to address them? Teachers themselves have offered some ideas. The 1994—95 TFS asked teachers who had moved from or
Figure 4: Percent teachers reporting various reasons were important for their turnover, by field

![Bar Chart]

Source: 2000–2001 Teacher Follow-up Survey

left their teaching jobs since the prior year to suggest possible steps schools might take to encourage teachers to remain in teaching. The responses for mathematics/science teachers are summarized in Figure 5.

One strategy suggested by departed teachers to aid retention is increasing salaries, which are, not surprisingly, strongly linked to teacher turnover rates. But salaries are not the only issue, which is important from a policy perspective because increasing overall salaries is expensive, given the sheer size of the occupation.

Reduction of student discipline problems is a second factor frequently suggested by departed teachers. Multivariate analysis of the data also documents that this factor is strongly tied to the rates of teacher turnover. Again, not surprisingly, schools with more student misbehavior problems have more teacher turnover (Ingersoll 2001). But, the data also tell us that, regardless of the background and poverty levels of the student population, schools vary dramatically in their degree of student misbehavior.
One of the factors tied to both student discipline and teacher turnover is how much decision-making influence teachers themselves have over school policies that affect their jobs, especially those concerned with student behavioral rules and sanctions. In a separate multivariate analysis of data from SASS, I have found that, on average, teachers have little say in many of the key decisions that affect their work; but schools where teachers are allowed more input into issues, student discipline in particular, have less conflict between staff and students and less teacher turnover (Ingersoll 2003b). Increasing teacher decision-making power and authority is also, not surprisingly, suggested by teachers as a step to aid retention. Class-size reduction was also frequently suggested by teachers as a step to increase retention. Surprising in Figure 5 is how few teachers suggested increasing support, such as mentoring, for new teachers as one of the main steps necessary for retention.

In a separate multivariate analysis of the 1999–2000 SASS data, we explored the impact of induction supports on the turnover of new teachers. After controlling for the background characteristics of teachers and schools,
we found a strong link between participation by beginning teachers in various induction activities and their likelihood of moving or leaving after their first year on the job (Smith and Ingersoll 2004). The data showed that the predicted probability of turnover of first-year, newly hired, inexperienced teachers who did not participate in any induction activities was 41 percent (see Figure 6). In contrast, after controlling for the background characteristics of teachers and schools, the turnover probability was 27 percent for beginning teachers who received what we labeled as some induction (had a mentor from their same field; had regularly scheduled collaboration or common planning time with other teachers in their subject area; had face time with the administration; and participated in beginners’ seminars). Twenty-six percent of beginning teachers received just these four components. Finally, a very small number (fewer than 1 percent of beginning teachers in 1999-00) experienced what we labeled as a full induction experience that included the above four components, plus three more: participated in an external network, had a reduced number of course preparations, and had a teacher aide. Participation in these activities had a very large and statistically significant impact—the probability of a departure at the end of their first year for those getting this package was less than half of that for those who participated in no induction activities.

**Implications**

Since the early 1980s, educational policy analysts have predicted that shortfalls of teachers resulting primarily from two converging demographic trends—increasing student enrollments and increasing teacher retirements—will lead to problems staffing schools with qualified teachers and, in turn, lower educational performance.

This analysis suggests, however, that school staffing problems for both mathematics/science and other teachers are not solely or even primarily due to teacher shortfalls resulting from either increases in student enrollment or increases in teacher retirement. In contrast, the data suggest that school staffing problems are also a result of a revolving door—through which large numbers of teachers depart teaching for reasons other than retirement.

Teacher turnover is a significant phenomenon and a dominant factor driving demand for new teachers. The data show that, while it is true that student enrollments are increasing, the demand for new teachers is primarily
Figure 6: Percent turnover after first year of beginning teachers, according to amount of induction support they received.

Source: 2000–2001 Teacher Follow-up Survey

due to teachers moving from or leaving their jobs at relatively high rates. Moreover, this analysis shows that, while it is true that teacher retirements are increasing, the overall amount of turnover accounted for by retirement is relatively minor when compared to that resulting from other causes, such as job dissatisfaction and seeking better jobs or other careers.

These findings have important implications for educational policy. Supply and demand theory holds that where the quantity of teachers demanded is greater than the quantity of teachers supplied, there are two basic policy remedies: increase the quantity supplied or decrease the quantity demanded. As noted in the beginning of this chapter, teacher recruitment, an example of the former approach, has been and continues to be a dominant approach to addressing school staffing inadequacies. This analysis suggests, however, that recruitment programs alone will not solve the staffing problems of schools if they do not also address the problem of teacher retention. In short, this analysis suggests that recruiting more teachers will not solve staffing inadequacies if large numbers of such teachers then prematurely leave.

What then can be done? From the perspective of this analysis, schools are not simply victims of inexorable demographic trends, and there is a signifi-
cant role for the management of schools in both the genesis of and solution to school staffing problems. Rather than increase the quantity of teacher supply, an alternative solution to school staffing problems, documented by this analysis, is to decrease the demand for new teachers by decreasing turnover. The data suggest that the way to improve teacher retention is to improve the conditions of the teaching job. Schools across the country where there is more support from the school administration for new teachers, such as induction and mentoring programs have significantly lower levels of teacher turnover. The same holds for schools with higher salaries, fewer student discipline problems, and enhanced faculty input into school decision-making. The data document that changing these things would all contribute to lower rates of turnover, in turn, diminish school staffing problems and, hence, ultimately, aid the performance of schools.

This chapter draws from an article that appeared in Science Educator in Spring 2003.

Appendix
Definitions of Measures of Reasons for Turnover
From a list of 17 reasons, the TFS teachers indicated the level of importance of each in their decision to move from their previous year's school or to leave teaching altogether. I grouped the 17 reasons into 5 categories, as follows:

- **Retirement.**
- **School Staffing Action:** reduction-in-force/lay-off/involuntary transfer.
- **Family or Personal:** change of residence; pregnancy/child rearing; health; other family or personal reason; take sabbatical.
- **To Pursue Other Job:** teach in another state, but certificate not accepted there; to pursue another career; to take courses to improve career opportunities within or outside the field of education; felt job security higher at another school; opportunity for better teaching assignment at another school.
- **Dissatisfaction:** dissatisfied with job; for better salary or benefits; school received little support from community; not agree with, or not feel prepared to implement, new reforms; dissatisfied with workplace conditions; lack of support from administration; lack of autonomy; lack of opportunities for professional development.
Richard M. Ingersoll

a former high school teacher, is a professor of education and sociology at the University of Pennsylvania. His research looks at elementary and secondary schools as workplaces, teachers as employees, and teaching as a job. He is a nationally recognized expert on the problems of underqualified teachers, teacher turnover, and teacher shortages. His book *Who Controls Teachers' Work? Power and Accountability in America's Schools* (Harvard University Press 2003) was the winner of the 2004 Outstanding Writing Award from the American Association of Colleges for Teacher Education.

References


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