INCREASING THE NUMBER OF MATHEMATICS AND SCIENCE TEACHERS: A REVIEW OF TEACHER RECRUITMENT PROGRAMS

Commissioned by the National Commission on Mathematics and Science Teaching for the 21st Century

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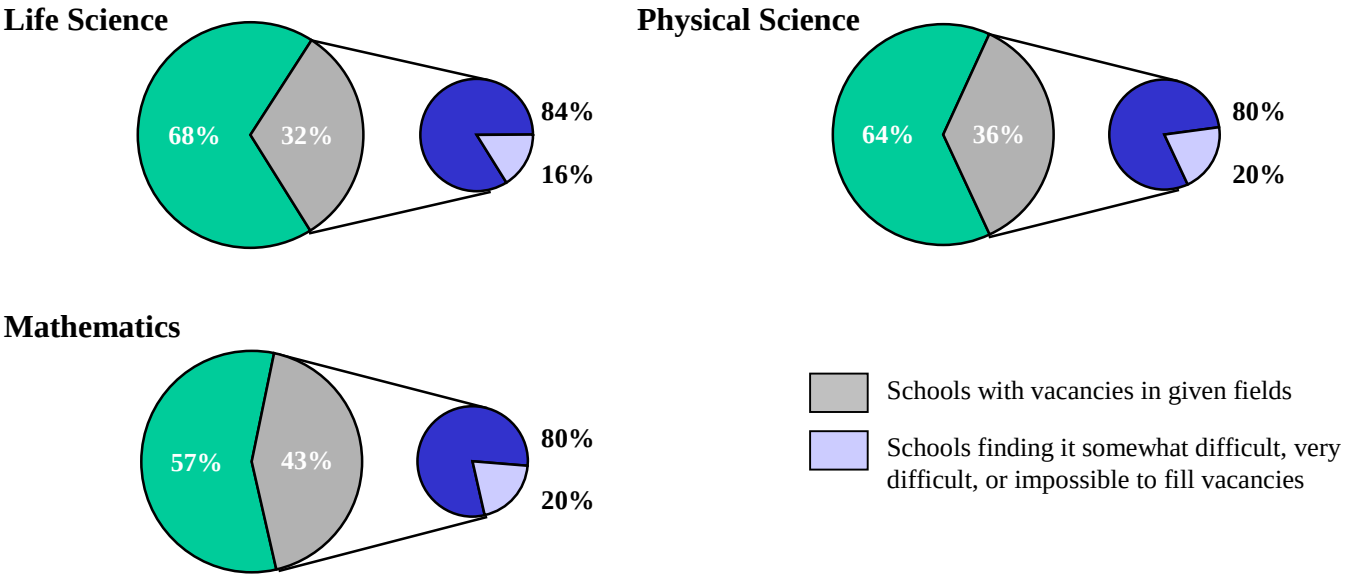
Introduction

Although there may be doubt concerning the predicted shortage of two million new teachers in the next ten years (Henry, 1999), there seems to be no question that there is in fact a shortage of mathematics and science teachers. As early as the beginning of the 1980s, shortages of mathematics and science teachers were being reported. The National Research Council established a panel in 1986 to study the problem (1990). Linda Darling-Hammond and colleagues reported in 1989 that there was convincing evidence that a shortage of mathematics and science teachers existed in most states; that there was a significant amount of out-of-field hiring and uncertified teachers were being assigned to teach these subjects; and that the number of newly prepared entrants to these fields had been declining (Darling-Hammond, Hudson & Kirby, 1989).

The situation has not improved today. More recent data from the National Center for Education Statistics (NCES) show that of the 43 percent of schools that had vacancies in mathematics in 1993-94, 20 percent reported difficulty in filling these vacancies (see Figure 1). Of the 36 percent of schools with vacancies in physical science, 20 percent found it difficult to fill these, and of the 32 percent of schools with vacancies in life science, 16 percent had difficulty staffing these positions (U.S. Department of Education, 1997).

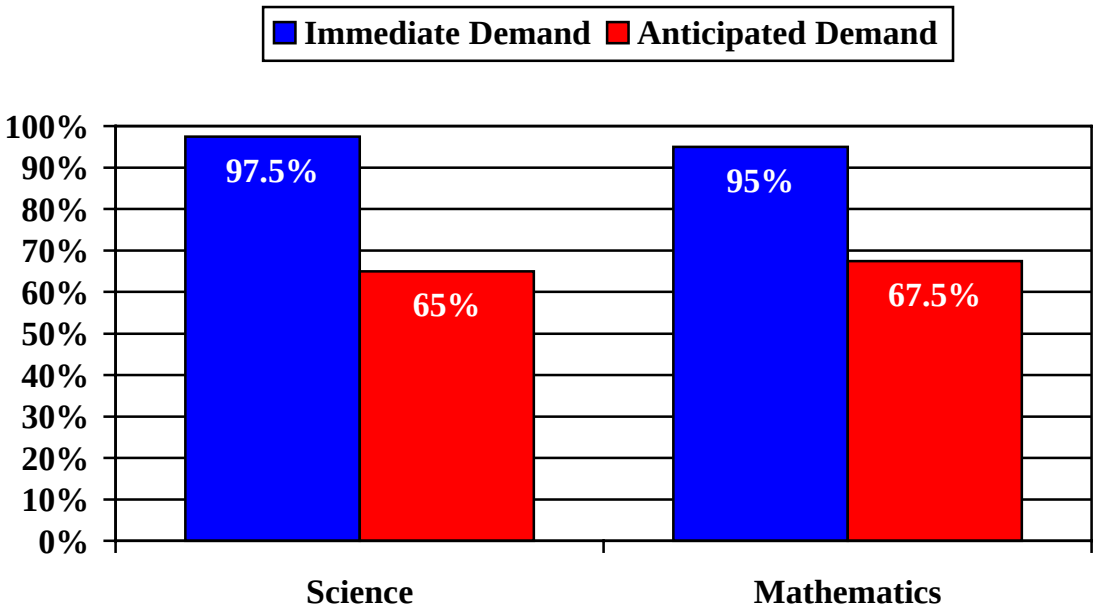
Figure 1. Difficulty in Filling Teacher Vacancies, 1993-94 (Percent of schools with teaching vacancies, by field, and percent that found them difficult to fill)



Source: NCES, America's Teachers: Profile of a Profession, 1993-94, 1997, Tables A8.11 a-e

These shortages are exacerbated in large urban school districts. In a recent survey of 57 large city school districts, 97.5 percent reported an immediate demand for high school science teachers, while 95 percent indicated an immediate demand for mathematics teachers (Recruiting New Teachers, Council of Great City Schools, and Council of the Great City Colleges of Education, 2000). At the same time, 65 percent and 67.5 percent of these districts indicated anticipated demands[1] for science and mathematics teachers, respectively. None of the districts surveyed indicated that they had no demand for science and mathematics teachers (see Figure 2).

Figure 2. Demand for High School Teachers in Science and Mathematics

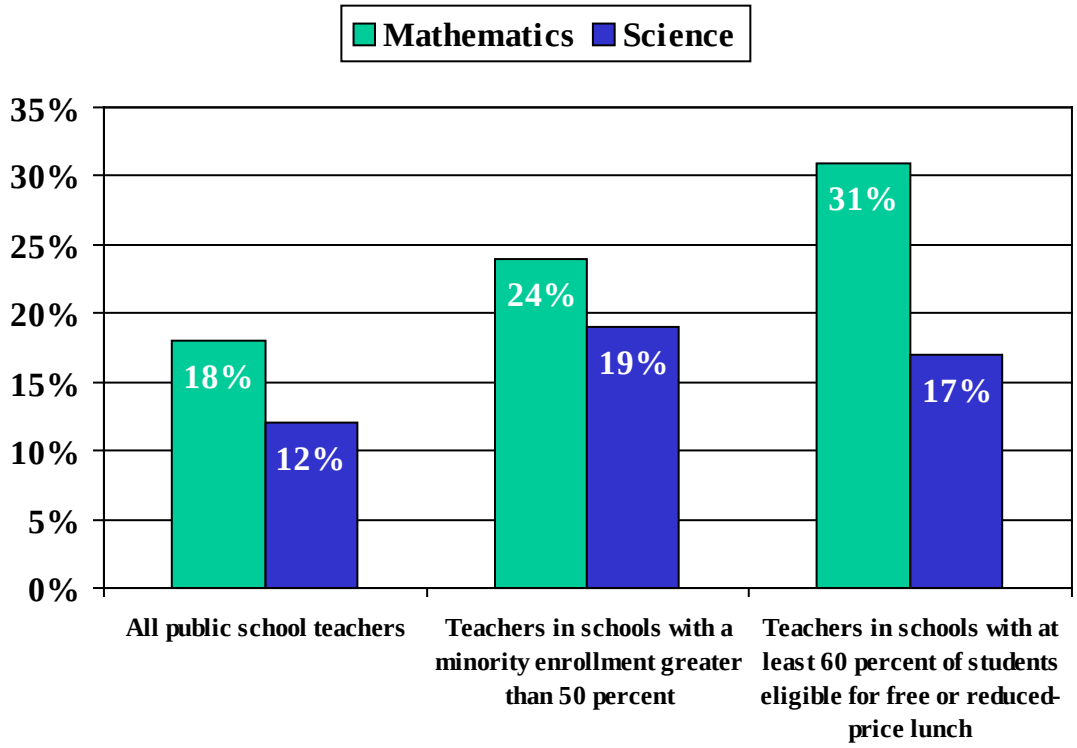


Source: Recruiting New Teachers, Inc., The Urban Teacher Challenge, p. 10.

In order to cope with the shortage of mathematics and science teachers, districts have resorted to a number of practices that threaten the quality of education students receive. Some districts have assigned teachers to teach mathematics or science classes out-of-field, which means that they teach subjects for which they do not have adequate preparation (an undergraduate or graduate major or minor in the teaching assignment field). Alternatively, districts have hired teachers with mathematics or science degrees who are not certified to teach these subjects. In 1998, 18 percent of all mathematics teachers and 12 percent of all science teachers in grades 7 through 12 reported that they were teaching out-of-field (U.S. Department of Education, 1999). Unfortunately, the situation is much worse in high-minority and in low-income schools. As Figure 3 illustrates, these schools have a much higher percentage of out-of-field teachers in mathematics and science than the general population. In high minority schools--that is, schools with over 50 percent minority enrollment--24 percent of mathematics teachers and 19 percent of science teachers teach out-of-field. In high poverty schools--where 60 percent or more of students are eligible for free or reduced-price lunch--31 percent of mathematics teachers and 17 percent of science teachers do not have either an undergraduate or graduate major or minor in their teaching assignment field.

[1] "Anticipated demand" covers demand expected for the next five years.

Figure 3. Percent of Math and Science Teachers (Grades 7-12) Teaching Out-of-Field, by Minority Enrollment and Free or Reduced-Price Lunch Eligibility



Source: U.S. Department of Education, NCES, Fast Response Survey System, Teacher Survey on Professional Development and Training, 1998

Obviously, stopgap measures designed to address emergency situations, such as the hiring of uncertified and out-of-field teachers, cannot solve the long-term problem of teacher shortages in mathematics and science. With teacher preparation and quality so closely linked to student achievement (Ferguson, 1991; Hanushek, Gomes-Neto & Harbison, 1992; Monk, 1994; Sanders & Rivers, 1996), practices of hiring uncertified teachers or assigning teachers out-of-field to mathematics and science classes will surely be detrimental to student achievement. Developments such as reductions in class size, the imminent retirement of a large percentage of the teaching force, high teacher attrition rates, and the growth in K-12 enrollments will require a massive infusion of new teachers overall, especially mathematics and science teachers.

In fact, from 1994 to 2005, education-related occupations will grow by 27 percent, the third highest growth rate in the nation (Occupational Outlook Quarterly, 1995). Complicating the problem is the relatively flat production of baccalaureate degree recipients among U.S. citizens and permanent residents in science, engineering, and mathematics fields (National Science Foundation, 2000a); the fact that science, engineering, mathematics, and computer science occupations are the second fastest growing areas in the economy (Occupational Outlook Quarterly, 1995); and the large differential in salaries earned by teachers versus those earned by engineers and scientists (Hudson Institute, 1999; U.S. Department of Education, 2000). What are viable approaches to solving the severe teacher shortage in mathematics and science?

There are two strategies for increasing the supply of workers in a given occupation: 1) increase the benefits or attractions of the position or 2) reduce the costs of entry (Kirby, Darling-Hammond & Hudson, 1989). The Federal government, states and local districts have attempted both approaches with varying levels of success.

In the remainder of this paper we will elaborate on the strategies that have been used in the past, and those that should be used in the future to reduce the shortage of math and science teachers. First, we describe national, state and local policies and programs aimed at alleviating the real and predicted teacher shortage in math and science. We then address the issue of effectiveness: how is it measured and what strategies have been effective in the past? In the subsequent section we discuss issues that are specific to the problems of recruiting teachers in these fields, such as the lack of a talent pool, the large salary differential that exists between teaching and other professions, and the issue of quality. Finally, we discuss the implications of these problems and the lessons to be learned from the available effectiveness data.

Policies and Programs Focused on Increasing the Recruitment of Mathematics and Science Teachers

In our review of national, state, and local recruitment policies and programs, we have sometimes included policies and programs that may not specifically focus on the recruitment of math and science teachers, but which have had success in attracting teachers to these fields nonetheless. Also included within these sections are programs that recruit teachers for shortage subject areas in high need school districts. Although these programs do focus on increasing the number of qualified math and science teachers, many focus on recruiting teachers to other shortage areas (such as special education).

National Policies and Programs that Increase the Number of Mathematics and Science Teachers

National Policies

On a national level, the primary policy effort targets reducing the cost of entry to a teaching career through loan forgiveness programs. The Teaching Service Cancellation/ Deferment Options provided by the federal government allow for the deferment and/or cancellation of federal loans if an individual becomes a full time teacher serving in a low-income or subject matter shortage area. Students with loans from the Federal Perkins Loan Program[2] become eligible for loan cancellation through teaching in an elementary or secondary school system that has a shortage of teachers in federally-designated shortage areas. These designated subject areas include both mathematics and science.

Students who have loan(s) under the Federal Direct Loan Program or the Federal Family Education Loan Program (FFEL)[3], do not qualify for cancellation, but may be eligible for loan

[2] Loan must have been made on or after July 23, 1992, to qualify.
[3] This includes Federal Stafford Loans, Federal PLUS Loans, Federal Consolidated Loans, and loans offered in earlier years through the Guaranteed Student Loan Program.

deferments of up to 3 years for full-time teaching in a federally-designated teacher shortage area[4]. Also, effective as of October 1, 1998, new Stafford Loan borrowers who become teachers in a federally designated teacher shortage area, are eligible for loan forgiveness after five consecutive, complete years in a shortage area (U.S. Department of Education, 1999).

National Programs

In response to the real and predicted teacher shortages in science and mathematics, the National Science Foundation created the Collaboratives for Excellence in Teacher Preparation (CETP). This is the only national program dedicated to recruitment and retention of teachers well qualified in mathematics and the sciences (National Science Foundation, 1998a). The program aims to effect significant systemic improvement in the SMET preparation of prospective preK-12 teachers. This is achieved via a collaboration of institutions, often including universities and colleges, two-year community colleges, and local high-need public school districts. As of 1998, there were seventeen CETP awards involving 175 institutions, including 69 two-year colleges (National Science Foundation, 2000b). This type of multi-layered collaboration has been found to be successful in producing preK-12 teachers who are not only competent and confident about their abilities in their subject area, but are also excited to incorporate science, math and technology activities into everyday classroom learning.

Funded programs seek to recruit and develop teachers who are sensitive to varied learning styles, backgrounds, and needs of students. In order to meet the immediate national demand for competent math and science teachers, non-traditional sources are tapped, such as paraprofessionals, or mathematicians, scientists and engineers contemplating career changes. Also, a particular effort is being made to recruit prospective teachers from underrepresented groups, in order to reshape the teaching workforce as a more accurate reflection of the student population that it teaches.

Illustrated in all of the reviewed teacher recruitment programs, a collaborative effort with institutional support can be utilized to accomplish various recruitment goals. The range of activities supported under the CETP program spans the continuum of teacher education. Activities undertaken by the Collaboratives include, but are not limited to:

- Curriculum development and reform;
- Recruitment;
- Coursework dealing with subject content, pedagogy and classroom management;
- Early and consistent field experiences; and
- Induction support for new teachers (National Science Foundation, 1998b).

[4] Loan must have been issued between July 1, 1987 and June, 30, 1993.

State Policies and Programs[5] that Focus on Increasing Recruitment of Mathematics and Science Teachers

In this section we will first discuss some of the policies that states have adopted to increase the benefits associated with joining the teaching profession. Second, we will describe two state recruitment programs that have proved effective in recruiting math and science teachers in their states (see Evidence of Effectiveness section).

State Policies

Recently, Education Week published their annual *Quality Counts* report (2000). In this edition, data were reported concerning policies that the states have enacted to recruit more people into the teaching profession. Five of the most prevalent recruitment policies, and the states that have adopted each, are displayed in Figure 4. These recruitment policies, many in the form of monetary incentives, represent attempts to counteract the projected nationwide teacher shortage. Unfortunately, *Quality Counts 2000* found that "most such incentives are weak and rarely focus on the schools or subjects where teachers are needed most" (Education Week, 2000, p. 8). For example:

- Twenty-seven states (54%) have developed web sites on which teacher job openings may be posted. However, most states do not require districts to participate, and therefore the listings, though convenient, remain incomplete. Also, only nine states allow prospective teachers to submit their application materials electronically.

- Twenty-seven states (54%) have some form of scholarship or loan forgiveness programs for prospective educators. However, only 11 states (22%) support policies targeting high achieving candidates for teaching, and only 10 states (20%) aim these programs at persons willing to teach in geographic shortage areas (rural and urban) and poor neighborhoods and underperforming schools. Further, despite the high demand for math and science teachers nationwide (see Figure 2), only 18 states (36%) target monetary incentive programs to persons willing to teach subject shortage areas such as math and science.

Looking towards the future, Massachusetts has become the only state thus far to institute a large signing bonus of $20,000 in a move to attract talented people into teaching careers. However, they may have started a trend: Maryland is scheduled to begin offering a signing bonus to their new teachers beginning with the 2000/01 school year (Education Week, 2000).

[5] There are a very small number of programs that attempt to address teacher shortages at the state level (see Clewell, Darke, Davis-Googe, Forcier & Manes, 2000). As a consequence, even fewer address the recruitment of math and science teachers at the state level. The two state programs reviewed here have been selected due to their success in recruiting math and science teachers, despite their lack of specific focus on these areas.

Figure 4. State Policy Matrix

State	Job openings posted on-line	Financial Incentives for Prospective Teachers			
		High – achieving candidates	Minority Candidates	Specific subject areas	Hard-to staff schools
Alabama					
Alaska	✓				
Arizona	✓				
Arkansas		✓	✓	✓	✓
California	✓			✓	✓
Colorado	✓				
Connecticut	✓		✓		
Delaware				✓	
Florida		✓	✓	✓	
Georgia	✓	✓		✓	
Hawaii				✓	
Idaho					
Illinois	✓	✓	✓	✓	✓
Indiana	✓				
Iowa				✓	
Kansas	✓				
Kentucky	✓		✓		
Louisiana				✓	
Maine	✓	✓		✓	
Maryland				✓	
Massachusetts	✓	✓			✓
Michigan					
Minnesota			✓		
Mississippi	✓				✓
Missouri		✓	✓	✓	

State	Job openings posted on-line	Financial Incentives for Prospective Teachers			
		High – achieving candidates	Minority Candidates	Specific subject areas	Hard-to staff schools
Montana	✓				
Nebraska					
Nevada					
New Hampshire					
New Jersey					
New Mexico	✓				
New York					
North Carolina		✓			✓
North Dakota					
Ohio	✓				
Oklahoma	✓			✓	
Oregon	✓				
Pennsylvania	✓				
Rhode Island					
South Carolina	✓		✓	✓	✓
South Dakota					
Tennessee		✓	✓	✓	✓
Texas	✓			✓	✓
Utah	✓	✓		✓	
Vermont	✓				
Virginia	✓		✓	✓	
Washington					
West Virginia	✓	✓			
Wisconsin	✓				
Wyoming	✓				

Totals for each state policy:
Number of states that have a web site posting teaching job openings on-line: 27 (54%)
Number of states that provide college scholarships, forgiveable college loans, or loan assumption to prospective teachers...
...who are minority candidates: 10 (20%)
...who are high achieving candidates: 11 (22%)
...who are willing to work in specific subject areas, such as math and science: 18 (36%)
...who are willing to work in hard-to-staff schools, such as rural and urban schools: 10 (20%)

State Programs

In describing the characteristics of state programs, we look at two programs. First is Troops to Teachers (see Text Box 1.), a program begun in January 1994 as a result of legislation introduced to offset military downsizing. It is a mid-career transition, referral and placement assistance program funded by the federal government[6], and managed by the Defense Activity for Non-Traditional Education Support (DANTES). Second is the North Carolina Teaching Fellows Program (see Text Box 2.), a high school recruitment program created by the Public School Forum of North Carolina in 1986, and funded by the North Carolina General Assembly. Although neither of these programs specifically targets mathematics and science teachers, both have been found to be successful in attracting people into math and science teaching careers.

Text Box 1. Troops to Teachers

Goals: The primary goal is to give retired and/or downsized military personnel and DoD civilian employees an entrance into a second career in public education. The secondary goal is to help fill the shortage of public school teachers, particularly in high-need geographic and subject areas.

Recruitment and Selection: Recruitment information exists primarily on their website. To be eligible for academic teaching, participants must have a baccalaureate degree from an accredited university. Those interested in vocational training are not required to hold a baccalaureate, but must be able to document their skill level in an alternative manner.

Academic Preparation: Troops to Teachers is primarily a referral and placement assistance program, and therefore no specific academic preparation is undertaken. However, the State Support offices assist participants in highlighting barriers to certification, and where possible, make arrangements to expedite the certification of participants.

Support Services: Troops to Teachers participants receive counseling and assistance to identify employment opportunities and teacher certification programs. State Program Managers assist participants in meeting certification requirements and locating potential jobs. Managers also support participants by networking with the local community in order to make the transition from military service to teaching an easier one for the participant. Another support service available to participants is an information and resource web site. Features on the site include public education job listings and on-line mentoring.

(Sources: Troops to Teachers Information Packet, 1999; Feistritzer, Hill and Willet, 1998.)

[6] Although the federal government funds Troops to Teachers, we consider it as a state program here because of the program's strong presence at the state level. Troops to Teachers currently has 21 state placement assistance offices. As of September, 1999, participants have been hired as teachers or teachers' aides in 49 states, the District of Columbia, Puerto Rico, and DoDDS overseas (Troops to Teachers Information Packet, 1999).

Text Box 2. North Carolina Teaching Fellows

Goals: The primary goal is to recruit academically talented North Carolina high school students into teaching careers. A secondary goal is to recruit greater numbers of male and minority teachers into North Carolina's public school system.

Recruitment and Selection: Teacher Recruitment Officers, present in all high schools, recruit top students to apply for the program. To be eligible, students must be legal residents of North Carolina and citizens of the US. The Fellows' selection process occurs at the school district and regional levels. Selection committees are composed of educational, political and community leaders from across the state.

Academic Preparation: The Fellows Program is a four-year undergraduate teacher education program that is offered through 14 of North Carolina's state colleges and universities. The curriculum includes early and extensive field experience, school visits, hands-on investigations into issues that challenge and define public schools, topical monthly seminars, and courses on leadership, at-risk students and cultural diversity.

Support Services: Fellows in the North Carolina program receive support services via dual academic advisors (one in liberal arts and one in teacher education). These advisors monitor the Fellows progress and serve in a mentoring capacity. Additionally, the Fellows receive financial support in the form of a scholarship/loan worth $26,000 ($6,500 yearly).

(Sources: Berry, 1995; Arnold and Sumner, 1992)

Local Programs that Focus on Increasing Recruitment of Mathematics and Science Teachers

In this section of the review, we will first discuss programs encompassed under the Department of Education's Title II Teacher Quality Enhancement Program – Teacher Recruitment Grants. Although the Teacher Recruitment Grants were not required to be math and science recruitment programs, seven of the twenty-eight programs funded do have components dealing with the recruitment of math and science teachers. Following this, we will describe the features of mid-career transition programs and alternative certification programs, using examples drawn from nine programs that recruit math and science teachers.

The U.S. Department of Education's Teacher Recruitment Grants: The Teacher Recruitment Grants[7]--awarded either to states or to partnerships between LEAs and teacher preparation institutions[8]--were created to recruit and prepare more people to become teachers. Funded programs focused on reducing shortages of qualified teachers who can teach in subject shortage areas and high-need school districts. Each project was required to complete an assessment of their partner district's most critical teacher needs, both actual and anticipated. They then designed and implemented activities that would meet these needs. For example, the Teacher Recruitment for Urban Schools of Tomorrow (TRUST) Project Partnership at Montclair State University identified the need for 25 full time secondary level math and science teachers at

[7] The Teacher Recruitment Grants program is a component of the larger Teacher Quality Enhancement Grants program as authorized by Title II of the Higher Education Act of 1965 (amended).

[8] Only two states, Hawaii and Connecticut, were awarded teacher recruitment grants, and neither of these has a particular focus toward recruiting math and science teachers. Hence our discussion of Teacher Recruitment Grants has been included in the local programs section.

the public schools they had partnered with. To address this need, the program targeted math and science majors from two local universities and prepared them for the classroom through supplemental secondary mathematics and science education courses. In this way, the Teacher Recruitment Grants allowed individual communities to determine their own needs and develop appropriate measures to meet them (U.S. Department of Education, 1998).

Of the projects funded by the U.S. Department of Education under the Teacher Recruitment Grant program, seven[9] were identified that (at least partially) focused their efforts on the goals of increased recruitment and improved preparation of math and science teachers, particularly in high-need districts. The major secondary goal is increasing the number of minority teachers in the teaching workforce. All seven programs made use of local partnerships. Local partnerships between school districts and teacher preparation institutions proved to be very effective at providing teachers for communities where they are most needed. The "grow your own" approach is an effective way to increase retention because individuals who are already members of a community are likely to remain there after they become teachers (U.S. Department of Education, 1998).

Due to the non-traditional nature of the programs, the target populations were varied, and many of the programs targeted more than one population. However, most programs indicated a preference for recruiting minority candidates. The target populations covered by the seven programs included:

- Minorities;
- Non-certified, mid-career, degreed adults (preferably with a degree in math, science or technology);
- Certified reentrants;
- Teacher aides;
- Military personnel;
- Teach for America graduates;
- Graduating college students with a degree in math, science or technology;
- Undergraduate college students who have not yet declared a major;
- Undergraduate college students with majors in math or science; and
- Graduating high school students who live in high-need areas.

[9] Programs discussed in this section are 1) the Teacher Quality Enhancement –Recruiting Project – Excellent Educators Ladder Program to Address Near-and Long-Term Teacher Shortages in High Need Southeast Alabama Schools at Troy State University; 2) TRI IT! at University of Tennessee at Chattanooga; 3)St. Louis Partnership for Excellence in Urban Teacher Preparation: A Teacher Recruitment Initiative at University of Missouri; 4) The Teacher Recruitment for Urban Schools of Tomorrow (TRUST) Project Partnership at Montclair State University; 5) Recruiting Talented and Diverse Individuals as Teachers for the Urban Classroom at Norfolk State University; 6) Southwest Texas Teacher Recruitment and Induction Project (TRIP) Partnership at Southwest Texas State University; 7) Teacher Recruitment Initiative at Bank Street College.

Participants for the programs were recruited and selected through a variety of methods. Many programs were advertised via media ads, word of mouth, referrals, and information seminars. Mailings and web site postings were used less frequently. One program utilized undergraduate entry-level courses as a forum in which instructors could integrate discussions about teaching the specific discipline as a career possibility. Participants to the programs were generally selected through an application and interview process. Most programs had initial academic requirements that the applicant had to fulfill before being considered, such as minimum education qualifications, and GPA standards. Two programs used the Urban Teacher Interview (Haberman, 1987) to assess whether applicants were suited to work in an urban school environment. Academic preparation for the participants varied, dependent on the level of education they held previous to entry. Nonetheless, most participants experienced a mixture of coursework, field-based experience and certification test preparation during their preservice education.

Support services were provided to participants during preservice and through the first three induction years of their teaching careers. These services included academic monitoring and advisement, tutoring, writing workshops, certification test preparation, preservice mentoring, web based mentoring, transportation stipends, book stipends, job placement, and induction support including mentoring. Programs provided financial support to participants in the form of scholarships designed to assist prospective teachers with payment of tuition, room, board, and other expenses. Scholarship recipients were required to commit to teaching in a high-need school district after completing the teacher preparation program. In the St. Louis Partnership for Excellence in Urban Teacher Preparation, financial assistance was additionally available to participants in the form of transportation and childcare allowances on a case by case basis. In a program run out of Norfolk State University an emergency cash fund was available to participants.

Local programs targeted at mid-career "switchers": In order to tap a new pool of talent, many programs at the local level utilize mid-career transition programs. These programs target highly motivated and capable individuals from professional and technical backgrounds with at least a bachelor's degree in a non-education major. Due to the specific focus on these programs on the recruitment of math and science teachers, most programs seek out individuals with a background in these fields. For some, such as the Crystal City Secondary Teacher Education Program, a deep recruitment pool exists in soon-to-retire military personnel. Program officers make a special effort to recruit these individuals by making presentations at the Pentagon and advertising their program in Pentagon newsletters.

An important component to any recruitment program concerns how the participants are academically prepared for their new career in the classroom. Preparation typically consists of a mixture of course work and field experience. For example, Mills College worked in cooperation with a nationally known science museum at University of California – Berkeley, area businesses and on-site staff to develop a unique curriculum consisting of coursework and field experience. Many programs, such as the California Mathematics and Science Teacher Corps Project and Project Promise at Colorado State University, admit recruits into already existing "fifth-year" education programs.

During the course of preparation, programs provide support services to their participants. Many provide academic support in the form of tutoring, academic advisors, and mentors. Some provide job placement assistance. For example, Project Promise at Colorado State University facilitates an extensive job search process on behalf of their participants that invites school districts from Colorado to interview candidates. Another form of support often offered is financial aid. Through its partnership with local aerospace companies, California State University – Dominguez Hills is able to provide financial support to participants throughout the course of their preparation. These funds cover the costs of tuition, texts and National Teacher Examination (NTE) fees.

Alternative certification programs: Another method by which local districts have accessed nontraditional pools of talent is through alternative certification programs. Alternative certification programs facilitate the accelerated entry of individuals into teaching careers through altered licensure requirements. Individuals with non-education bachelor's degrees are targeted. One example, Teach for America[10], recruits recent college graduates from all academic majors to commit to teaching for two years in an understaffed urban or rural school. To reach these students, recruitment activities take place on over 100 campuses across the nation (Teach for America, 1999). Other alternative certification programs, such as the Houston Independent School District (HISD) program, recruit participants in more traditional ways, through newspaper, radio and television (Morgan, 1998; Morgan, 1999).

Academic preparation provided by alternative certification programs varies greatly. For example, while Teachers for Chicago participants enter a master's degree program consisting of course work and a two year internship degree (Kamin, 1999; Chesek, 1998), recruits to the Teach for America program take part in a five-week summer training institute before entering the classroom (Teach for America, 1999). HISD participants receive 72 hours of pre-assignment training, including a week of field experience. Once they begin their assignment, interns continue their preparation with further coursework and HISD training (Morgan, 1998; Morgan, 1999). Interns in the Los Angeles Unified School District (LAUSD) Intern Program attend a 15-day preservice training program consisting of seminars and two days in the field. Following this, interns take part in training sessions once a week for two years (Stoddart, 1990).

Alternative preparation programs also provide support services to their participants. Many, such as the LAUSD Intern Program, provide mentors. Participants of the intern program receive mentoring support for two years from a trained mentor (Stoddart, 1990). Another form of support often offered is financial aid. Through its partnership with the Chicago Public Schools, Teachers for Chicago is able to provide participants with funding to earn their master's degree in education at a participating university. In return for this assistance, participants agree to teach in Chicago Public Schools for two years following the completion of their degree (Kamin, 1999; Chesek, 1998).

[10] Although Teach for America is a national program, we have included it here because all its work takes place at the local level.

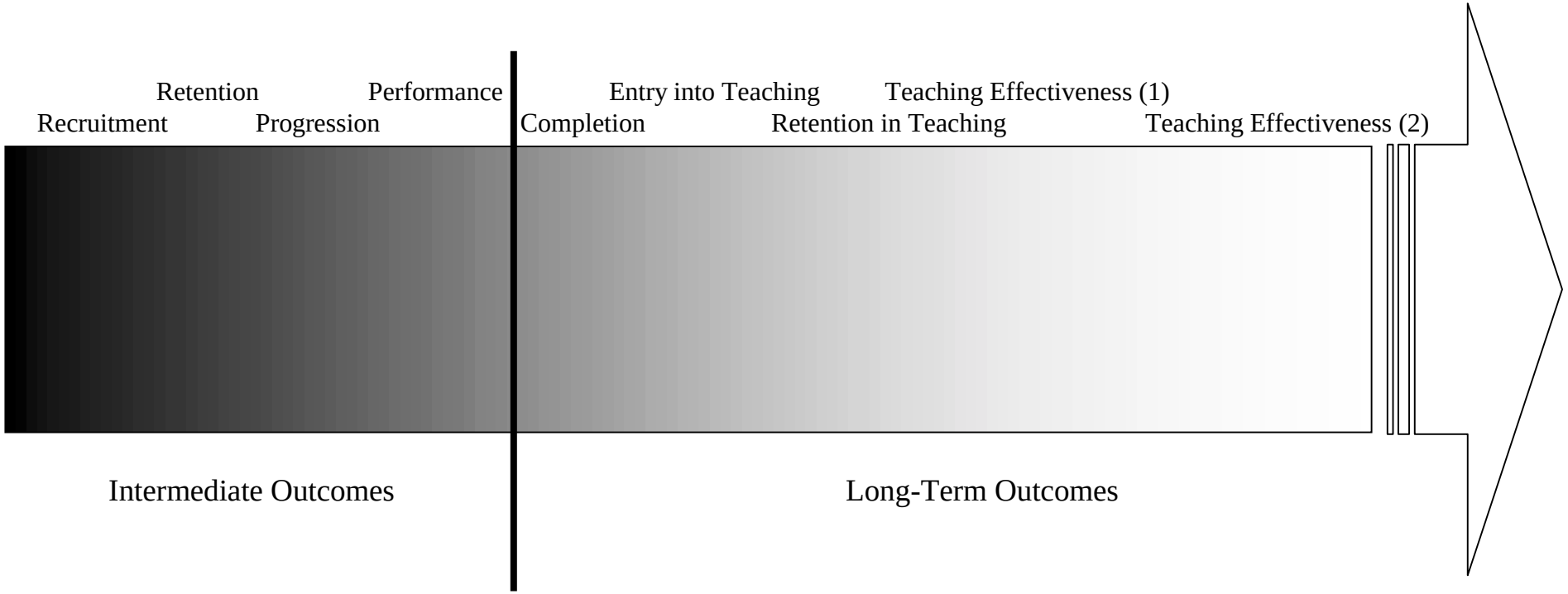
Policies and Programs to Increase the Number of Mathematics and Science Teachers: How Do We Judge Effectiveness?

Measures of Effectiveness

The effectiveness of programs can be measured in phases along a continuum against which the following questions can be arrayed (see Figure 5):

- Has the program succeeded in recruiting the targeted population of students in terms of number, characteristics and quality of students? [Recruitment]
- Have participants been retained in the program? [Retention]
- Have participants made good progress through the program to attain certification? [Progression]
- Have participants performed well in their programs? [Performance in Program]
- Have participants completed the program and attained certification? [Completion]
- Have participants entered teaching in mathematics and science? [Entry into Teaching]
- Have participants remained in teaching? [Retention in Teaching]
- Are participants good teachers? [Teaching Effectiveness (1)]
- Do participants' students show higher levels of achievement than students of traditionally prepared teachers? [Teaching Effectiveness (2)]

Figure 5. Continuum of Outcomes Used to Measure Program Effectiveness



To answer each of these questions, indicators of success (Figure 6) must be developed and data collected on each of the indicators:

Figure 6. Indicators of Success

INDICATOR OF SUCCESS	RECOMMENDED DATA COLLECTION
Recruitment	Number of participants recruited Demographic characteristics Prior preparation/experience
Retention	Number of participants who remain in program over a period of time (in years) divided by the # of participants enrolled
Progression	Percent of participants who have completed within a predetermined period of time
Performance in Program	GPA or grades in teacher education, if applicable
Completion	Percent of participants who have completed requirements for certification Percent of participants who have completed certification
Entry into Teaching	Percent of participants who have obtained teaching jobs in math and science
Retention in Teaching	Percent of participants who are still in teaching after a three-year period; after a five-year period; etc.
Teaching Effectiveness (1)	Principals' mean rating of participants compared to ratings of other beginning teachers
Teaching Effectiveness (2)	Comparison of participants' students' standardized test scores with those of other teachers, controlling for student characteristics, educational resources, and teacher experience

Most of the above indicators can be compared to a comparison group of similar individuals to ascertain whether the program has had an effect greater than that which could be expected if the program did not exist. Of course, given different target populations, indicators for each question might differ based on the type of population being served. For example, time to completion (progression) would be much longer for a paraprofessional (who does not have a bachelor's degree) than for a career-switcher or a teacher receiving retraining. When assessing effectiveness, some consideration should also be given to the cost of the program, although few programs report cost. Comparing the costs of preparing individuals from different populations for teaching might lead to a decision to focus on one or two populations that have the lowest cost per teacher given the outcomes achieved.

Effectiveness of Nontraditional Recruitment Programs

Many of the efforts to boost the number of mathematics and science teachers have been through nontraditional recruitment programs. Nontraditional teacher recruitment programs, like those described in the preceding pages, attempt to find, recruit and prepare for teaching careers persons who were not initially attracted to traditional undergraduate preparation programs, while still requiring that these recruits be certified in order to teach their subjects. Kirby, Darling-Hammond, and Hudson have classified these programs into three different types[11]. While some of the programs we discussed above fall into these categories, the descriptors listed below were developed by Kirby and her colleagues in the course of their research.

(1) *Nontraditional recruitment programs* that recruit potential teachers from nontraditional pools and provide them with coursework and other requirements for full certification in mathematics and/or science without requiring any changes in state policies; (2) *alternative certification programs* that also recruit from nontraditional pools and prepare participants to meet revised teacher certification requirements (these programs do require changes in state policy); and (3) *retraining programs* that are designed to assist teachers already prepared in other fields to obtain certification in mathematics and/or science (no changes in state policy required) (1989). Additionally, the nontraditional recruitment programs are divided into: programs that target midcareer "switchers" from other mathematics and science related fields into teaching and recently graduated students with baccalaureate degrees in these fields.

In summarizing the evaluative findings of a study of 64 nontraditional programs to increase the number of mathematics and science teachers, Kirby and her colleagues (1989) found that:

- Recruits in these programs are more likely to be minority, female and older
- They represent a wide range of backgrounds and experiences
- Most have prior teaching experience although they are not fully prepared to enter K-12 classrooms
- Graduates of these programs enter and remain in teaching at rates comparable to (and perhaps higher than) those for traditionally prepared teachers
- Graduates of these programs do not have difficulty finding teaching positions
- Graduates of these programs express the desire to remain in teaching for about as long as graduates of traditional teacher preparation programs (recruits who entered the program from a BA program seem to be the least likely to enter and remain in teaching).

The study concluded that nontraditional programs seem to be at least as effective as more traditional programs in preparing teachers for the classroom. The 64 programs that were reviewed enrolled over 2,000 science and mathematics candidates among them. The researchers felt, however, that the benefits of the cost-reduction strategy offered by the programs could not totally overcome the disadvantages of joining the teaching profession (Kirby, Darling-Hammond, & Hudson, 1989). Several of the participants in their study expressed dissatisfaction with teaching and their current teaching assignments. For example, new recruits experienced "reality

[11] These programs can be national, state or local programs.

shock" upon beginning their classroom duties, finding that student discipline and motivation were two of the most difficult problems. Participants were also dissatisfied with their salaries and the level of respect they received from their students. Seventy percent responded that they planned to remain in teaching for a while, but only about half stated that they planned to make teaching a career (Kirby, Darling-Hammond, &Hudson, 1989).

Of current mathematics and science teacher recruitment programs[12], we identified and reviewed the evaluation data of seven programs. The programs described below vary in scope and were selected because their available evaluation data was sufficient for some judgments concerning effectiveness.

National Level Programs

The National Science Foundation's Collaboratives for Excellence in Teacher Preparation (CETP): In CETP institutions, over a four-year period from 1995 to 1998, 43,389 baccalaureate degrees were earned by undergraduates preparing to become teachers. In addition, 55,828 post-baccalaureate students were preparing to become teachers at these institutions, with about 37, 200 completing post-baccalaureate certification programs. Approximately, 80,600 new teachers have been produced from CETP institutions over this time period.

Of the 26,386 CETP 1998 graduates who were surveyed in 1999, 50 percent were teaching. Also in 1998, 42 percent of the undergraduates preparing to become teachers in CETP institutions were members of minority groups (National Science Foundation, 2000b).

State Level Programs

North Carolina Teaching Fellows Program: The program effectively recruited high-caliber participants as evidenced by higher SAT scores and GPAs than nonparticipating peers. The participant pool contained a higher percentage of males and minorities than are in the national teaching pool. Principal ratings show Fellows to be more effective teachers than non-Fellow peers. Data are not yet available on retention in teaching.

Troops to Teachers: As of September 1999, the program has been effective in recruiting 3,355 former armed forces and civilian employees of the Department of Defense into teaching. Also, TTT has recruited much higher percentages of minorities, males, and math and science teachers into the teaching force than are represented in the national teaching force. No data on teacher effectiveness or retention in teaching were available, although 67 percent of TTT alumni reported that they intended to teach until retirement.

Local Level Programs

Houston Independent School District (HISD) Alternative Certification Program: Since 1986, the program has been successful in recruiting 3,500 teachers; the male and minority

[12] The programs detailed below focus on increasing the number of teachers in shortage areas, including mathematics and science.

representation in the pool of interns is higher than that of the national pool of teachers. Participants perform better on the certification exam than over half of the students from conventional programs, with minority groups outperforming more than two-thirds of the minority students in traditional programs. First-year teachers who were program participants were rated at least as highly on a formal teacher appraisal instrument as a sample of non-program first-year teachers.

Los Angeles Unified School District (LAUSD) Intern Program: From 1984 to 1990, the program recruited 1,100 new teachers into the district; currently, 300 new teachers are being prepared each year. The program has brought about a decrease in the percentage of emergency-certified teachers in the district and a concurrent increase in the percentage of program participants, while the supply of college-trained teachers has remained the same. Data on courses taken in academic major, GPA and institution attended, show that interns in the program are well prepared academically in their subject areas. After three years, interns have also remained in teaching at a higher rate than the national retention average for teachers at the three-year mark.

Teach for America: Since 1996, TFA has placed 2,317 individuals as teachers. Individuals recruited by the program are more likely to be minorities and to be high achieving college students. The completion rate of the two-year commitment to teach (88 and 89 percent) shows it to be high. Data on retention in teaching beyond the two-year period is not available. Teacher effectiveness data has been collected on a subset of participants but not enough information is available on sample size and response rates to allow us to judge the validity of the data.

Teachers for Chicago: Completion rates show that the program, which targets 100 participants a year, is exceeding its yearly recruitment target. Long-term outcome data also show that the retention rate of the first two cohorts of teachers who exited the program exceeds the five-year national retention rate.

Unfortunately, few teacher recruitment programs collect and report evaluation data. A review of several of these programs revealed only a handful with credible evaluations (Clewell et al., 2000). Failure of programs to evaluate their effectiveness deprives the field of valuable information about successful approaches and strategies in recruiting teachers.

Issues Unique to Recruiting Mathematics and Science Teachers

A number of issues are unique to the recruitment of mathematics and science teachers. Chief among these are the scarcity of individuals in the reserve pool for science and mathematics teaching and the differences in salary earned by science professionals[13] in contrast to that of mathematics and science teachers.

[13] This term is inclusive of both mathematics and science professionals.

Lack of a Talent Pool

The labor market demand for individuals trained in science has been increasing dramatically. Between 1994 and 2005, jobs in scientific, engineering, mathematical, and computer science occupations will be the second fastest growing in the country (Occupational Outlook Quarter, 1995). At the same time, growth in the percentage of degree recipients in these fields has remained quite stagnant, with numbers of degree recipients (who are U.S. citizens and permanent residents) in fields such as engineering and computer science, which are most in demand, actually declining (National Science Foundation, 2000a). These data suggest that there is and will continue to be, great competition among science occupations and with teaching for new graduates in science, engineering, and mathematics fields. An analysis of the National Science Foundation's Surveys of Scientists and Engineers reveals that experienced scientists and engineers rarely entered teaching and, when they did, very few remained in teaching for more than one or two years (Darling-Hammond, Hudson & Kirby, 1989).

Large Salary Differentials

This situation will only intensify the large salary differential between science professionals and teachers. For example, of 1992-93 bachelor's degree recipients who were employed full-time in 1997, the average annual salary of scientists/engineers was $39,000 compared with that of K-12 teachers, which was $25,500[14] (U.S. Department of Education, 2000). Although, in general, the real cost to new bachelor degree recipients of choosing teaching as a career remains high for all fields, it is particularly so for those with degrees in computer science, mathematics, and physical science (U.S. Department of Education, 1993).

The lack of individuals in the reserve pool and the large differences in salary between science professionals and teachers of mathematics and science, make the task of recruiting teachers for these subjects more difficult than for most other subjects.

Quality Issues

The reform movement in mathematics and science education and the development of national mathematics and science standards have required changes in the preparation of mathematics and science teachers. Elementary teachers are being asked to complete more credit hours in science and mathematics courses and it has been suggested that the preparation of mathematics and science secondary teachers be expanded considerably (Center for Science, Mathematics, and Engineering Education, 1997; Monk, 1995; Shugart & Hounshell, 1995). The movement toward increasing the preparation of mathematics and science teachers is supported by research showing a positive relationship between teacher content knowledge and methods preparation (as measured by the number of courses in these areas) and student learning of mathematics and science (Monk, 1995). This emphasis on increased course work has implications for the cost of preparing mathematics and science teachers as well as the time it will take for them to complete degree or certification requirements.

[14] Salaries for teachers were computed on a nine-month basis.

The work of Darling-Hammond and colleagues (1989) on the characteristics of teaching entrants from the mathematics and science talent pool reveals that these entrants to teaching come from the lower-paying end of the scientific occupational spectrum. This study also shows that subgroups within the pool, such as those working in the service sector, those with education degrees, and those involved in teaching or training on the job, are more likely to enter teaching.[15] What is the depth of content knowledge in mathematics and science possessed by this subgroup? One would guess that it is not as extensive as that of science professionals. This finding is supported by research that shows a significant relationship between subject knowledge in science and recruitment and retention of science teachers. Teachers who scored higher on subject matter knowledge were more likely either never to teach or to drop out of teaching after a short time (Shugart & Hounshell, 1995).

The issues discussed above are unique to the recruitment of teachers of mathematics and science. They contribute to the complexity of an already complex problem: that of increasing the supply of professionals from a severely depleted talent pool in the face of fierce competition and in the absence of significant attractions or incentives.

Lessons Learned/Policy Implications

Directly addressing the issues that are unique to the recruitment and retention of mathematics and science teachers is clearly a step in the right direction. Drawing from the descriptive and effectiveness data available in this report, there are lessons to be learned about reducing the teacher shortage.

First, programs utilizing a partnership structure, such as universities working with local school districts, can yield multiple beneficial results. Partnerships facilitate the exchange of information concerning the teaching needs of communities. This improved communication between school districts and institutions of teacher preparation results in more appropriately designed projects, and easier placement for newly prepared teachers. Also, by sharing resources, financial and otherwise, partners can alleviate the cost burden of supporting a teacher recruitment program and better provide participants with comprehensive support services.

Clearly, without a pool of people to recruit from, a program's preparation strategies are irrelevant. As is illustrated in the discussion of state and local programs, looking at nontraditional sources for potential science and mathematics teachers can prove highly effective, and is often more so than traditional recruitment. By drawing from nontraditional pools of people, whether mid-career "switchers", retired military personnel, or undeclared undergraduates, states and districts could improve poor teacher retention rates, as people who enter the teaching field through nontraditional routes tend to remain in teaching for a longer duration. Focusing recruitment efforts more narrowly on populations in the mathematics and science talent pool that have been found to be more likely to enter teaching fields (such as those from the lower-payment

[15] Interestingly, retirees were not likely to be part of the reserve pool. This is unfortunate because, with the "graying" of the U.S. population, there will be a large number of retired scientists and engineers who might be recruited into teaching.

end of the scientific occupational spectrum, those working in the service sector or involved in training) is a strategy we recommend.

One of the most prevalent problems associated with low recruitment and retention of mathematics and science teachers is poor salary. Current teacher salaries are both a barrier and a disincentive to the teaching career, particularly considering that people with comparable math and science skills earn far more when they enter the business or IT world. In order to attract people to the teaching profession at any level and then keep them, teachers' salaries should reflect teaching as a profession – not as a lesser-valued occupation.

Another financial strategy that states and local programs should consider when recruiting math and science teachers is forgiveable loans and scholarships. This type of cancellation of debt is currently available at the national level, but with expanded implementation could prove a powerful ally in attracting people to the profession.

Finally, lack of data remains a major barrier to ascertaining the most effective strategies to reduce the teacher shortage in science and mathematics. Without data, we cannot evaluate the strengths and weaknesses of a program and thereby measure its effectiveness. Data collection and evaluation are crucial to discovering and replicating strategies and programs that are truly successful.

Additional suggestions or recommendations that have not emerged from this review should also be considered.

- Community college students majoring in science, mathematics and technology fields represent a good source of math and science teachers. Structuring community college education to ensure adequate preparation and counseling during the first two years to facilitate easy transfer to a four-year college is essential to opening up a pathway through two-year colleges into math and science teaching.

- Many undergraduates majoring in mathematics, engineering and science, especially women and minorities, switch out of these majors midway through their four years of college. Estimates of the occurrence of switching out of math and science majors are as high as 70 percent. These students represent another pool from which to recruit math and science teachers.

- What about the 46 percent of individuals who prepare for teaching but do not enter that occupation immediately after graduation from college? Can those with math and science education training be encouraged into teaching right after graduation?

- Finally, recruitment efforts should also focus on individuals with graduate degrees in fields such as the life sciences where jobs are not plentiful.

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