

# Archived Information

## Secretary's Mathematics and Science Initiative Teacher Knowledge Working Group Report

### Introduction

The primary goal of the Teacher Knowledge Action Plan is to ensure that all components of mathematics teacher education link together to create a seamless set of career experiences for teachers. We envision a system that produces and sustains teachers who understand both mathematics and children's learning. The system incorporates policy support at all levels so that preservice education, credentialing procedures, induction, professional development programs, and opportunities for teacher leadership are connected.

We do not currently have a continuous system of training and professional development for teachers that includes early coursework, clinical experiences, induction, and career pathways supported through ongoing development <sup>1,2</sup> The Teacher Knowledge Action Plan seeks to create partnerships of professional organizations, foundations, businesses, publishers, school systems, colleges and universities, states, and federal agencies that result in a more coherent and effective system of support for teachers.

We want the teaching of mathematics to be viewed as a true profession. Therefore, all teachers must have a sound knowledge of mathematics and a desire to develop the habits of mind required for a rigorous understanding of the subject. Professional teachers must be aware of and versed in an array of sound pedagogical methods and continually study, practice, examine, and compare new and old ideas about teaching. Professional teachers are informed by research on student learning and continuously experiment with incorporating research-based practices into their classrooms. Those who enter the profession from other mathematics or science careers need opportunities to link their professional knowledge and experience to the knowledge base in teaching and learning and the realities of working in classrooms.

The five-year Action Plan focuses on the career experiences of teachers in grades K-8 because of the urgency we feel for increasing their content knowledge and teaching skills in mathematics. Many elementary teachers have had few courses in mathematics as a part of their undergraduate preparation, and 65.2% of middle school students are taught by teachers without a major or certification in mathematics. <sup>3</sup>

The research base for mathematical teaching and learning is under-developed and incomplete, and one of the major goals of the overall Secretarial initiative for

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<sup>1</sup> National Research Council. *Educating Teachers of Science, Mathematics and Technology: New Practices for the New Millenium*. Washington, DC: National Academy Press, 2001

<sup>2</sup> Bransford, J.D., Brown, A.L. and Cocking, R.R. (EDs.) *How People Learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press, 1999.

<sup>3</sup> Seastrom, M.M., Gruber, K.J., Henke, R.R., McGrath, D.J., and Cohen, B.A. (2002). Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987-88 to 1999-2000 (NCES 2002-603), tables B-8 and B-9. Data from the U.S. Department of Education, NCES, Schools and Staffing Survey (SASS), "Public Teacher Questionnaire," 1999-2000 and "Charter Teacher Questionnaire," 1999-2000.

mathematics is to support more research in this area. Based on what we know, however, we have confidence that increasing teachers' content knowledge and related teaching skills can contribute to better teaching and student learning. The *Background Paper* for the Mathematics Initiative summarizes the research base on which the Action Plan is based.

The Action Plan follows a similar sequence that recognizes the different needs teachers have at various stages in their career. These stages are: preservice, induction, inservice, alternative route and mid career, and teacher leader. Within each of these stages, the Action Plan recommends activities to: (1) identify the most promising practices and research available; (2) promote implementation of practices based on the promising practices and research; (3) develop networks and communication venues to support individuals and groups engaged in the work; and (4) conduct evaluation and research on the work carried out as a part of the Action Plan in order to further develop the knowledge base on improving teacher quality.

## Primary Goal

*All elementary and middle school teachers will have strong mathematics content knowledge and teaching skills to meet States' requirements that all teachers be highly qualified by the NCLB target date of 2005-2006. Veteran teachers will have opportunities to develop high levels of expertise as they move through their careers.*

### Overview

The Action Plan addresses two of the most significant issues in mathematics education – the need for greater content knowledge and related teaching skills, and the need for improved training and professional development to develop this knowledge. While much more research is needed in these areas, there is some evidence that provides guidance to this document:

- Teacher quality characteristics such as a degree in the field to be taught are significantly and positively correlated with student outcomes.<sup>3</sup>
- Many elementary and middle school teachers report that they do not feel they have sufficient background in the mathematics they teach.<sup>4</sup>
- According to NCES data, in 1999-2000 the majority (65.2%) of middle school students are taught mathematics by teachers that have neither an undergraduate major or certification in mathematics. Teachers with elementary certification most often have very little academic preparation in mathematics.<sup>5</sup>
- For elementary and middle grade students to become proficient in mathematics, it is critical that their teachers have a solid understanding of the mathematical concepts they teach and are skilled in content-based instructional practices.<sup>6</sup>
- Professional development for elementary and middle school teachers who need more content knowledge in mathematics requires intensive instruction in mathematics. This is best accomplished through sustained professional development organized around key content and that takes place over time.<sup>6</sup>

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<sup>43</sup> Sanders, W., & Rivers, J. (1996). Cumulative and residual effects of teachers on future student academic achievement. Knoxville, TN: University of Tennessee Value-Added Research and Assessment Center

<sup>54</sup> Weiss, I., Pasley, J., Smith, P.S., Banilower, E.R., & Heck, D. J. (2003). "Looking inside the classroom".

<sup>5</sup> U.S. Department of Education, National Center for Education Statistics. 2002. Qualifications of the Public School Teacher Workforce: Prevalence of Out-of-Field Teaching 1987-88 to 1999-2000. Washington, DC: GPO, Tables B-11 and B-12.

<sup>6</sup> David Cohen and Heather Hill. *Learning Policy: When State Education Reform Works*. New Haven and London. Yale University Press. 2001.

- Veteran teachers with strong content knowledge and teaching skills benefit from opportunities to provide leadership within the schools to develop further their knowledge and skills, and expand their career options. More advanced opportunities can entice them to stay in the teaching profession and allow them to contribute in a significant way to the overall improvement of schools.<sup>7</sup>

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<sup>7</sup> <http://www.cpre.org/Publications/rb31.pdf> (page 7)

## Career Experiences of Teachers: PRESERVICE EDUCATION

**Pre-Service Goal:** Arts and Science faculty in collaboration with Education faculty of Institutions of Higher Education (IHEs) will offer teacher preparation programs that include significant preparation in appropriate mathematics content, and related teaching skills.

### *Background*

There are over 1,300 teacher preparation institutions with a wide range of program designs. The programs usually contain components that include subject matter coursework, pedagogical preparation, and clinical training. Sound research on teacher preparation programs is sparse and more is needed.<sup>8</sup>

The nature and quantity of the subject matter preparation needed by prospective teachers is a ripe area for more research.<sup>10</sup> However, enough evidence has accumulated to provide a starting point for the Action Plan. Although the appropriate kind or amount of subject matter preparation has not been determined conclusively by research, there is a positive correlation between teachers' subject matter preparation and their effectiveness in the classroom.<sup>9</sup>

Greater involvement by arts and science faculty in partnership with colleges of education and school and local school districts is a promising strategy for improving teacher-education programs.<sup>11</sup> This involvement allows for increased attention to content knowledge with courses taught by content experts who are actively engaged in their fields. In many cases, the mathematics disciplinary faculty have not been actively involved in preparing preservice teachers, but it makes sense that mathematics departments should have a responsibility for increasing prospective teachers' knowledge in the discipline.

### *Action Strategies*

- (1) Develop frameworks for undergraduate courses and course sequences that identify the mathematical knowledge required by elementary and middle school teachers. Mathematicians must be centrally involved in this work in collaboration with mathematics educators and teachers. The frameworks serve as a basis for

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<sup>8</sup> U.S. Department of Education. "A Talented, Dedicated and Well-Prepared Teacher in Every Classroom". <http://www.ed.gov/PDFDocs/speakerskit.pdf>.

<sup>10</sup> Meeting the Highly Qualified Teachers Challenge. The Secretary's Second Annual Report on Teacher Quality. See page 48.

<sup>9</sup> Meeting the Highly Qualified Teachers Challenge. The Secretary's Second Annual Report on Teacher Quality. See pages 44-51.

<sup>11</sup> No Child Left Behind – Title II

developing and field-testing undergraduate mathematics courses offered to teachers.

*Responsible:* Mathematicians, mathematics educators, national professional associations, university leaders.

*Outcome:* Frameworks for pre-service teacher preparation programs that provide thorough preparation in mathematics.

- (2) Encourage the development and evaluation of courses and course sequences in undergraduate preparation programs that embody the frameworks recommended in Strategy 1. Analyze existing materials, textbooks, and courses to determine their match to the frameworks' recommendations. These efforts should involve collaborations between schools of arts and sciences (A&S) and schools of education (ED), and should be supported by the president or chancellor to ensure visibility and on-going support of the work.

*Responsible:* Institutions of Higher Education, Local School Districts, Foundations, Business community.

*Outcome:* Preservice preparation programs that improve the mathematics content of prospective teachers and improve collaboration between A&S and ED departments at IHEs.

- (3) Improve the accountability systems available to assess K-8 preservice teachers' content knowledge. The assessment systems should take account of both the frameworks developed in Strategy 1 regarding the mathematical content teachers need to know, and the requirements of NCLB.

*Responsible:* States, National Testing Companies, IHEs.

*Outcome:* Assessments of K-8 pre-service teachers' content knowledge that embody the frameworks developed in Strategy 1.

- (4) Review and modify certification requirements based on assessments of teachers' mathematical content knowledge developed in Strategy 3 and on the frameworks developed in Strategy 1.

*Responsibility:* States, Institutions of Higher Education

*Outcome:* State certification requirements for K-8 teachers that embody the frameworks developed in Strategy 1 and use assessments developed in Strategy 3 to measure the mathematical content knowledge of prospective K-8 teachers.

- (5) Create networks to communicate information on and provide support for improving preservice mathematics learning and the assessment of that learning. Examples of useful networks could include mathematicians responsible for teaching preservice teachers, IHE department heads and deans, and state policy makers overseeing teacher assessment and certification.

*Responsible:* Professional Associations, Foundations, IHEs, State Agencies.

*Outcome:* Support and information for individuals and groups revising the mathematics courses and assessments offered to K-8 preservice teachers.

- (6) Conduct research and evaluation studies on the effectiveness of undergraduate mathematics courses offered to K-8 preservice teachers. Collect existing research and evaluation studies. Evaluate programs developed under Strategy 2.

*Responsible:* Professional Organizations, Federal Agencies, States, IHEs.

*Outcome:* An analysis of the research and evaluation data on efforts to improve the content knowledge in K-8 preservice teachers, and identification of successful programs. A compendium of successful inservice programs, with evidence on why the programs worked and the results that were achieved will be developed.

## **Career Experiences of Teachers: INDUCTION**

**Induction Goal:** States and districts will establish comprehensive induction programs to support novice K-8 teachers of mathematics.

### ***Background***

A significant number of teachers (up to 50% in some areas) leave teaching within five years, and research on their reasons for leaving found that many cited lack of support and difficult working conditions as the greatest problems [citation]. While many places offer some kind of support for beginning teachers, many of these programs are superficial, involving little more than assigning a mentor teacher to provide limited support.<sup>13</sup> Relatively few programs provide support over time, and even fewer offer systematic help with content knowledge and related teaching skills.

### ***Action Strategies***

- (1) Develop a set of promising practices for high-quality and extensive induction programs. These might include: mentoring programs; sustained relationships between IHEs and districts to continue the development of teachers' content knowledge; assignment policies that do not burden new mathematics teachers with the most challenging students and overwhelming schedules; and, on-going assessment of teachers' skills and content knowledge. Promising practices will be identified based on their potential to improve retention rates of new teachers and support development of pedagogical skills and knowledge that are linked to mathematics content.

*Responsible:* Federal Agencies, Professional Societies, Local School Districts.

*Outcome:* A set of promising practices for induction programs are developed and disseminated.

- (2) Develop and evaluate model induction programs and policies that are based on the promising practices developed in Strategy 1. Encourage support for novice teachers that includes mathematical content knowledge and teaching skills. Advocate for stronger induction programs.

*Responsible:* School Districts, IHEs, States, Professional Associations.

*Outcome:* Examples of induction programs that improve the skills and retention rates for new teachers, and that have evaluation data on the strategies that were successful..

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<sup>13</sup> Britton, E., Paine, L., Pimm, D., & Raizen, S. (2003). Comprehensive teacher induction: Systems for early career learning. Dordrecht/Boston/London: Kluwer Academic Publishers.



- (3) Establish an interactive, online network for such groups as novice elementary and middle school mathematics teachers, veteran teachers and administrators with responsibility for the orientation of new teachers. The networks should provide support for new teachers as well as provide a forum for exchange of ideas about successful approaches to induction.

*Responsible:* Local Districts, Federal Agencies, Professional Societies, and Business Groups.

*Outcome:* Networks that support new teachers and the veteran teachers and administrators who work with them. The networks permits online discussion groups, information sharing such as research, evaluation, proven teaching practices, and ways to understand and teach complex content.

- (4) Conduct research and evaluation studies on induction programs and policies to determine which programs are the most successful and why they are successful. Evaluate programs developed under Strategy 2. Providers of induction programs should document their evaluation results and submit them for review and dissemination.

*Responsible:* Federal Agencies, State Agencies, IHEs, and Foundations.

*Outcome:* Successful, research-based practices on induction programs are identified and disseminated. A compendium of successful professional development programs, with evidence on why the programs worked and the results that were achieved.

## **Career Experiences of Teachers: INSERVICE PROFESSIONAL DEVELOPMENT**

**Inservice Goal:** State and local education agencies will provide substantial professional development opportunities that increase teachers' mathematical content knowledge and teaching skills, leading to improvement in student learning.

### ***Background***

Research has indicated that teacher quality is an important factor in increasing student achievement, and that on-going professional development should be viewed as a prerequisite for retaining a well-qualified teaching force<sup>3 15 16</sup>. Fifty-two percent of middle grade mathematics teachers do not have a major or minor in mathematics<sup>5</sup>, indicating a lack of content knowledge as they enter the profession. The 1999 evaluation of the Eisenhower Professional Development Program suggests that successful professional development focuses on strengthening teachers' content knowledge and on how students learn particular content, but that these areas are not the norm for most professional development that is offered.

The Third International Mathematics and Science Study (TIMSS), as well as other studies, have challenged the nation to make the school mathematics program more ambitious. To implement more challenging curricula, a substantial investment in teacher professional development is needed. Many teachers will need to learn more complex content than their original training provided.<sup>14</sup>

### ***Action Strategies***

- (1) Develop a set of promising practices for high quality professional development opportunities in mathematics for inservice teachers. The promising practices should include as attention to: the content knowledge required to teach effectively at various grade levels; effective teaching strategies; how much professional development is needed to effect changes in teacher behavior (duration); effective formats for delivering professional development; how content, format, and duration should match the purpose of professional development and the current skill levels of the teachers; and, examples of high quality professional development. As part of identifying promising approaches to professional development, state NCLB plans for highly qualified teachers of elementary and middle school mathematics should be analyzed.

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<sup>15</sup> Ronald Ferguson. Paying for Public Education: New Evidence on How and Why Money Matters. Harvard Journal of Legislation, Vol. 28 (Summer 1991), 465-498.

<sup>16</sup> Greenwald, R., Hedges, L.V., Laine, R.D., The effect of school resources on student achievement. Review of Educational Research, Vol. 66 (Fall 1996), 361-396.

<sup>14</sup> William H. Schmidt, et al. *Why Schools Matter: A Cross-National Comparison of Curriculum and Learning*. Published by Jossey Bass in San Francisco, 2001

*Responsible:* Federal agencies, Professional Associations, States and local school districts, IHEs.

*Outcome:* A set of promising practices that provide guidance on effective professional development is developed and widely disseminated.

- (2) Conduct analysis of existing professional development programs to determine the degree to which they align to the promising practices identified in Strategy 1. Based on this analysis, professional development programs are redesigned, implemented, and evaluated to determine their effectiveness.

*Responsible:* States, Local School Districts, Universities, and Professional Organizations.

*Outcome:* High quality professional development opportunities are developed, implemented, and evaluated.

- (3) Assess the quality and effectiveness of professional development opportunities and curriculum materials offered by professional organizations and other non-school based groups to determine how they align to the promising practices identified in Strategy 1. These groups should determine how their work supports the important curricular goals established by states or districts.

*Responsible:* Professional Organizations, Informal Education Organizations, Scientific Societies, IHEs, Foundations, Business Groups.

*Outcome:* Stronger implementation of specialized curricula and professional development and better evaluation results on these efforts.

- (4) Establish on-line networks of groups providing professional development to teachers within specialized areas, with the purpose of supporting their efforts and sharing information.

*Responsible:* Professional Organizations, Professional Development Providers, Federal Agencies, Universities, States, Local School Districts.

*Outcome:* Enhanced communication and support among professional development providers.

- (5) Research and evaluate professional development efforts that align with the promising practices identified in Strategy 1. Professional development providers should document their evaluation results and submit them for review and dissemination.

*Responsible:* Federal Agencies, Professional Development Providers.

*Outcome:* A compendium of successful professional development programs, with evidence on why the programs worked and the results that were achieved.

## Career Experiences of Teachers: ALTERNATIVE CERTIFICATION PRACTICES AND CAREER CHANGERS

**Alternative Certification Goal:** States and districts will design alternative certification programs that facilitate and support promising candidates entering the mathematics teaching profession.

### *Background*

The shortage of highly qualified teachers is more acute in the area of mathematics than in most content areas<sup>17</sup>. Many of the traditional teacher training and state licensure systems are under-producing highly qualified mathematics teachers.<sup>18</sup> If schools are not able to attract talented people and keep them in the classroom, student academic performance will suffer.<sup>19</sup> The difficulty of adequately staffing classrooms with qualified teachers is more severe in schools serving low-income, high minority enrollment, urban or extremely rural communities.<sup>20</sup>

Alternative route programs have been successful in recruiting a more diverse pool of teachers, and all but nine states have approved an alternative route to certification<sup>17</sup>. Alternative routes that require high standards for admission, substantial pedagogical training, mentoring, and evaluation tend to be more successful in producing highly qualified teachers.<sup>21</sup>

### *Action Strategies*

- (1) Develop a set of promising practices for mathematics teachers entering the profession from alternative routes, including those entering at mid-career. These should include: a diagnostic system to identify capabilities of prospective elementary or middle school mathematics teachers in mathematical content knowledge; systems of high-quality professional development geared specifically to the wide-ranging interests and needs of individuals entering the professions from alternative routes; examples of effective administrative support for these individuals; examples of effective assignment policies that do not burden new mathematics teachers with the most challenging students and overbearing schedules.

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<sup>17</sup> National Association of State Boards of Education. October 2002. "State incentive programs for recruiting teachers: Are they effective in reducing shortages. Issues in Brief. Alexandria, VA: NASBE.

<sup>18</sup> U.S. Department of Education, Office of Postsecondary Education. 2002. Meeting the Highly Qualified Teachers Challenge. Washington, DC.

<sup>19</sup> Prince, C.D. (2002). Higher pay in hard-to-staff schools: The case for financial incentives. Arlington, VA: American Association of School Administrators.

<sup>20</sup> The Education Trust. All Talk, No Action. <http://www2.edtrust.org/NR/rdonlyres/8DE64524-592E-4C83-A13A-6B1DF1CF8D3E/0/AllTalk.pdf>.

<sup>21</sup> [http://www.abell.org/pubsitems/ed\\_cert\\_1101.pdf](http://www.abell.org/pubsitems/ed_cert_1101.pdf); <http://epaa.asu.edu/epaa/v10n36.html>;  
[http://www.abell.org/pubsitems/ed\\_cert\\_rejoinder\\_1101.pdf](http://www.abell.org/pubsitems/ed_cert_rejoinder_1101.pdf).

The promising practices should include individuals entering the profession through alternative routes, and individuals who change from other careers into teaching, focusing on their preparation in mathematics content knowledge and teaching skills.

*Responsible:* National and State Entities Providing Alternative Routes to Teaching, Mathematics Groups, Federal Agencies.

*Outcome:* A set of promising practices for alternative routes and mid career programs for mathematics teachers.

- (2) Review and revise alternative certification requirements based on the promising practices identified in Strategy 1. Develop and evaluate programs and other mechanisms to ensure that teachers entering through these routes are encouraged, and receive strong preparation and support in mathematics.

*Responsible:* State Education Agencies, Local School Districts, Institutions of Higher Education.

*Outcome:* Stronger and more varied alternative routes for bringing talented individuals into teaching mathematics.

- (3) Establish networks of programs and individuals involved with alternative routes to certification in order to share information, expertise, and advice.

*Responsible:* Professional Organizations, Federal Agencies, IHEs, States, Local School Districts.

*Outcome:* Enhanced communication and information sharing among groups and individuals involved with alternative routes to certification.

- (4) Conduct research and evaluation to identify and develop successful alternative route programs. Focus especially on programs developed under Strategy 2.

*Responsible:* Federal Agencies, States, Foundations, Professional Organizations.

*Outcome:* Dissemination of successful sound evaluation results on effective alternative route programs.

## Career Experiences of Teachers: TEACHER LEADERSHIP

**Teacher Leadership Goal:** States and districts will establish programs to identify, support, and deploy a cadre of teacher leaders in mathematics to work as mentors, resource teachers, demonstration teachers, peer coaches, and professional development providers.

### *Background*

Accomplished and veteran teachers are critical to the success of schools. Their experience and wisdom are important resources, but are often not called upon as often as they could be in efforts to improve schools. Often, veteran teachers feel they have to move out of the classroom in order to have a broader impact and more varied professional opportunities.

The TIMSS study has identified key practices in high performing countries that draw on the knowledge of experienced teachers. For example, in Japan teacher leaders collaborate to develop lessons that are taught in the school through a process of development, testing, and revision. In addition, teacher leaders are responsible for training new teachers, and work with them over several years before the new teachers are allowed to assume a full teaching load. These sorts of leadership opportunities diversify the work responsibilities of veteran teachers, which is important in retaining them in the profession.

### *Action Strategies*

- (1) Develop a set of promising practices on effective professional development opportunities in mathematics for veteran teachers, and on ways that teacher leaders can contribute to improving mathematics instruction in the schools. These should include such opportunities as: learning specialized, advanced mathematics; leadership training; understanding student learning and cognition; and, understanding how to work with adults as a mentor. In addition, effective ways that teacher leaders can work within schools should be identified.

*Responsible:* National Organizations, Federal Agencies.

*Outcome:* A set of promising practices that can be widely disseminated.

- (2) Offer professional development programs and leadership opportunities for teacher leaders that are aligned with the promising practices identified in Strategy 1. These opportunities should be carefully evaluated to determine what practices best contribute to teacher learning at an advanced level and help to keep exemplary teachers in the classroom.

*Responsible:* School Districts, Institutions of Higher Education, Professional Organizations.

*Outcome:* Expanded opportunities for veteran teachers.

- (3) Develop opportunities at the school, district, state and national level for teacher leaders to participate in activities, including: mentoring novice teachers, developing curricula and analyzing existing materials, participating in ‘teacher in residence’ programs, providing professional development, among others. These opportunities should be based on promising practices developed in Strategy 1 and aimed at keeping exemplary veteran teachers involved in work that is directly relevant to teaching and learning.

*Responsible:* Schools, Local School Districts, States, Professional Organizations, Professional Development Providers.

*Outcome:* A diverse array of professional opportunities for teacher leaders that keep them engaged in work directly relevant to instruction is available.

- (4) Establish networks to support teacher leaders and those developing strategies for supporting the development of teacher leaders.

*Responsible:* States, Local School Districts, Institutions of Higher Education, and Professional Organizations.

*Outcome:* Greater collegiality and support for teacher leaders and others working with them.

- (5) Conduct research and development studies on how best to support the development of teacher leaders. Evaluate programs developed under Strategy 2 and Strategy 3.

*Responsible:* Federal Agencies, Institutions of Higher Education, Local School Districts.

*Outcome:* A stronger research and evaluation base on effective ways to work with veteran teachers is available. A compendium of successful approaches to working with veteran teachers, with evidence on why the approaches worked and the results that were achieved.