

New Mexico Project 2012

Chapter 1. Producing More K-12 Math and Science Teachers with Better Content and Pedagogical Preparation

Abstract

Unless action is taken, New Mexico will soon be facing a serious shortage of high school math and science teachers. The situation is most critical in math, where the addition of a required fourth year course for high school graduation will substantially aggravate an already tenuous situation. In both math and science, New Mexico is not graduating enough teachers each year to account for normal attrition.

In addition, more must be done to equip New Mexico's K-12 math and science teachers with the content knowledge, pedagogical skill, confidence and enthusiasm necessary to teach these subjects effectively. This is a critical issue, as many student attitudes toward math and science are formed in elementary school years and must be nurtured in middle school for success in high school.

1.1. Statement of the Issues

This chapter is concerned with two issues: (1) the preparation of a sufficient number of qualified, licensed, high school math and science teachers to supply New Mexico's increasing need; and (2) the adequacy of current teacher preparation practices.

1.1.1. Rate of Teacher Preparation

In the 2007-2008 academic year, New Mexico's public teacher preparation institutions prepared 26 high school math teachers and 27 high school science teachers in their regular programs. Also, 27 math-endorsed high school teachers and 30 science-endorsed high school teachers were teaching on Internship Licenses while in Alternative Licensure Programs (see Appendix 1.1). In 2008-2009 the total for both regular and alternative licensure programs was only 40 high school math teachers and 44 science teachers.¹ Since there are presently over 1100 teachers of high school math (with about 900 fully licensed and endorsed), and over 900 teachers of high school science (with about 700 of them fully licensed and endorsed), it is clear that the number of math and science teachers we are currently producing does not even replace those leaving through normal attrition (e.g. retirement or relocation), let alone add those necessary to deal with increased curricular demands.² Other recruitment approaches should be explored, such as attracting high school math and science teachers from out of state (e.g. from *Teach for America*³ and *Troops to Teachers*⁴ programs), inducing more retired teachers in New Mexico back into service, and attracting STEM (Scientific, Technical, Engineering and Mathematics) professionals into the teaching ranks.

1.1.2. Avenues for Licensure and Certification of Pre-Service K-12 Teachers

New Mexico's K-12 math and science teachers choose from among the six different teaching licenses listed below.

¹ Educator Accountability Reporting System (EARS) Report, Legislative Education Study Committee, New Mexico State Legislature, December 2009.

² Starting with those entering grade 9 in 2009, New Mexico students will need four mathematics courses rather than three to graduate high school.

³ www.teachforamerica.org

⁴ www.proudtoserveagain.com

- Elementary Education, Grades K-8
- Middle Level Education, Grades 5-9
- Secondary Education, Grades 7-12
- PreK-12 Specialty License
- Special Education PreK-12
- Early Childhood Education, Birth-Grade 3

The six most common pathways to these teaching licenses⁵ are via:

- Traditional Undergraduate Licensure Program
- Master's + Licensure Program
- Alternative Licensure Program
- Pathway Alternative Licensure
- Portfolio Pathway
- District Alternative Licensure Pathway

To teach math or science, it is necessary to be “highly qualified” for grades 6-8, or “endorsed” for grades 7-12 or PreK-12. To obtain an initial license, the requirements to be “highly qualified” in grades 6-8 math or science are 24 credit hours and passing the *New Mexico Content Knowledge Assessment*⁶ in middle-level math or science. To be “endorsed” in grades 7-12 on an initial license, the requirements are 24 credit hours (12 of which must be in upper division or graduate courses) and passing the *Content Knowledge Assessment* in secondary-level math or science. If one already has an initial license, one can become “highly qualified” or “endorsed” with either 24 credit hours or passage of the appropriate *Content Knowledge Assessment*.

Beginning in Fall, 2009 all teachers obtaining a “K-8” license are required to take nine credits of math and 12 credits of science. Until recently New Mexico required only six hours of math, but following an MSAC recommendation the State Legislature passed into law (House Bill HB322, 2009) an increase to nine hours. This affects all undergraduates entering pre-service education programs starting in Fall, 2009.

1.1.3. General Principles of Pre-Service Teacher Education

As discussed above, there are many pathways that teachers take to become certified to teach mathematics and science. In elementary school, teachers are generalists who teach all subjects, while middle and high school teachers must have content-specific endorsements. Whether prospective teachers pursue licensure as undergraduates straight out of high school, or come to teaching after a career in some other field, the programs they pursue must help them develop the foundation for a deep, coherent understanding of the subject area they will teach and begin to equip them with the knowledge and skills to teach for understanding. To help them see the connections between their own learning in math and science, and the work that they will do as teachers, courses for prospective teachers should utilize high-quality K-12 math and science curricula. Such courses, whether taught in Colleges of Education or Colleges of Arts and Sciences, should be specifically designed for future teachers.

⁵ www.ped.state.nm.us/Licensure/ or www.teachnm.org

⁶ www.nmta.nesinc.com

However, there are concerns about the adequacy of current teacher preparation practices (see page 12). The *Math and Science Town Hall Final Report*⁷ recommended that “Colleges and universities ... increase the rigor of mathematics and science requirements for teachers entering teacher education programs and licensure by increasing the number of credit hour requirements and/or the quality of mathematics and science courses ...”

In addition, entry-level competencies for math and science teachers have not been revised for over ten years.⁸ During that time both the Conference Board of Mathematical Sciences (CBMS)⁹ and the National Science Teachers Association (NSTA)¹⁰ have made important suggestions for improving the initial preparation of math and science teachers, organized around the four pillars of an ideal pre-service preparation program:

1. Development of strong content knowledge for the grade level to be taught.
2. Development of a deep knowledge of how children learn and how to facilitate student learning in classroom settings.
3. Early classroom experiences with strong teachers.
4. A cohort structure that builds a community amongst prospective teachers in order to support each other through a rigorous but rewarding program of study.

Institutions of higher education that prepare pre-service teachers are strongly encouraged to work together to develop assessments (or utilize existing assessment tools and protocols) for these courses to be sure that their students are developing the kind of deep mathematical and scientific knowledge needed to teach school mathematics and science. Assessments should measure basic content knowledge as well as “pedagogical content knowledge”¹¹ (the content-based knowledge that is specialized for teaching).

1.1.3(a). Pre-Service Elementary School Teacher Preparation

Most elementary school teachers are expected to be experts in the teaching and learning of all elementary school subjects. Yet a four-year program of preparation may not provide the depth of knowledge needed in all areas. It is critical to help prospective math and science teachers develop the foundational knowledge and skills needed for a deep understanding of their subjects. The *New Mexico Mathematics and Science Standards*¹² should be used for guidance here, with respect both to specific content and to the processes by which math and science are learned and taught. For example, teachers who plan to teach grades K-3 need specific knowledge in early numeracy, assessment and instruction. This is especially true in light of the Response to Intervention initiative¹³ and the introduction of math intervention teachers¹⁴ in the early grades (see also Chapter 2, pg. 27). Suggestions for courses that could help provide better preparation for elementary school math and science teachers appear in Appendix 1.2. In addition, instructors

⁷ <http://web.nmsu.edu/~pscott/Town%20Hall%20Final%20Report.pdf>

⁸ A redesign of the math entry-level competencies began in Fall, 2009.

⁹ *Mathematical Education of Teachers*, www.cbmsweb.org/MET_Document/

¹⁰ *Standards for Science Teacher Preparation*, www.nsta.org/about/positions/preparation.aspx

¹¹ Shulman, L. *Knowledge and Teaching: Foundations of the New Reform*. Harvard Educational Review, 57 (1987) 1.

¹² The New Mexico Math Standards are available at www.ped.state.nm.us/MathScience/mathStandards.html and the Science Standards are at www.ped.state.nm.us/MathScience/scienceStandards.html.

¹³ www.ped.state.nm.us/RtI/

¹⁴ Math intervention teachers work directly with students identified as being significantly behind grade-level expectations.

of pre-service elementary teachers should model in their classrooms the kind of instruction that teachers are expected to use when in service.

The *Mathematical Education of Teachers* document⁹ recommends that prospective elementary grade teachers be required to take at least nine semester hours on fundamental ideas of elementary school mathematics. As already indicated, New Mexico now requires nine credit hours. This represents real progress. It must now be matched with adequate curricula and assessment.

In response to *Version 1.0 of New Mexico Project 2012*, specific comments were received from the *National Council on Teacher Quality* (NCTQ).¹⁵ Their principal recommendations were: (1) that New Mexico should re-examine its single-course preparation standard for K-8 teachers, recognizing that middle school mathematics teachers need different courses than do elementary teachers; and (2) that the math licensure test be redesigned to put a substantial emphasis on the math segment score rather than simply on the aggregate score over all content areas. The recommendation also suggested that the math component should aim much higher in terms of content knowledge.

There is a considerable body of evidence that the mathematical preparation of elementary school teachers has historically been inadequate. In 1999, Liping Ma¹⁶ compellingly argued that elementary teachers need a “profound understanding of elementary mathematics” and she showed that many American (over half of the sample was from New Mexico) elementary teachers do not have it. A recent report¹⁷ from the NCTQ evaluated the entrance requirements and course syllabi of the eight New Mexico institutions of higher learning¹⁸ that provide undergraduate preparation for pre-service teachers. The principal findings express concerns about:

- Very low (“almost meaningless”) admission standards;
- Generally poor coverage of the math content that elementary teachers need, and that algebra preparation is universally inadequate;
- Only one program has selected a strong text for math content coursework; and
- No assurance that aspiring elementary teachers understand math content at a depth sufficient for instruction.

Though there are some justifiable concerns about the methodology used by NCTQ in reaching these conclusions,¹⁹ the findings reflect what many New Mexico math educators already believe: that significant work is needed to improve the mathematical proficiency of elementary teachers. However, this will not be achieved simply by modifying the syllabus or textbook for a pre-service teacher course. More meaningful changes are needed. In some cases this work has already begun:

- To give substance to the recently increased number of math courses required for elementary school teachers, a task force of mathematicians, math educators and K-8 teachers is working on revising the K-8 math teacher entry level competencies. However,

¹⁵ www.nctq.org. Letter from Bess Keller to Secretary of Education Veronica García (December, 2008).

¹⁶ Ma, L. *Knowing and teaching elementary mathematics : teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, N.J.: Lawrence Erlbaum Associates (1999).

¹⁷ “*Preparing Tomorrow’s Teachers: Are New Mexico’s education school graduates ready to teach reading and mathematics in elementary classrooms?*” (Sept. 2009) www.nctq.org/p/publications/docs/nctq_daniels_new_mexico.pdf

¹⁸ College of Santa Fe, Eastern New Mexico, New Mexico Highlands, New Mexico State, Northern New Mexico College, University of New Mexico, University of the Southwest, and Western New Mexico.

¹⁹ LESC testimony, <http://www.nmlegis.gov/lcs/lesc/lescdocs/briefs/November2009/Item%208%20-%20NCTQ%20Report.pdf>

the new and improved competencies will lack teeth unless the New Mexico mathematics assessment for teachers is revised to reflect these higher standards.

- In order to assess the effectiveness of math for elementary teachers courses, some IHEs have begun to pilot assessments of mathematical knowledge for teachers to determine if pre-service elementary teachers are learning the mathematics that they need to know. However, this effort needs to be stepped up and expanded in a timely fashion. It would ideally include math methods courses as well as math content courses.
- In 2005, New Mexico increased the requirement for future middle school math teachers, who now must take 15 credit hours of math beyond the nine credit hours of math required of all K-8 teachers. Furthermore, middle school math teachers must pass a specific assessment on middle school math content. The middle school mathematics competencies are also currently being revised, and the middle school assessment will also need to be strengthened accordingly.

While New Mexico is addressing many of the concerns identified by the NCTQ and other researchers, more ongoing and substantial work needs to be done as indicated.

1.1.3(b). Pre-Service Middle School Teacher Preparation

The overall situation in middle school is somewhat complicated. “Regular” middle schools incorporate grades 6 to 8, where math and science teachers must be “highly qualified” or “endorsed” in the content they are teaching, but there are also K-6 and K-8 schools where “generalists” teach math and science along with the other core and supporting subjects. In “regular” middle schools, some of the math and science teachers have “Elementary K-8” licenses, some have “Secondary 7-12” licenses, and some have “PreK-12 Specialty” or “Special Education” licenses. New Mexico does have a “Middle 5-9” license, but none of our public teacher preparation institutions have programs for it, so the few teachers in New Mexico that hold such a license have either added it or come from out of state.

The CBMS⁹ and NSTA¹⁰ reports have specific suggestions for the preparation of middle school science teachers that are different from those for the elementary generalist and high school science teachers. Suggestions for courses that could help provide better preparation for middle school math and science teachers appear in Appendix 1.3.

1.1.3(c). Pre-Service High School Teacher Preparation

The traditional preparation for high school math and science teachers has been a bachelor’s degree (or equivalent) in the discipline. But there is increasing recognition that for high school math teachers to know mathematics for teaching²⁰ and high school science teachers to know science for teaching, they need at least a capstone²¹ course that addresses pedagogical content knowledge. The situation is also complicated by the fact that high school science teachers in New Mexico get an endorsement in general science and so must be prepared to teach all the basic high school scientific disciplines. Suggestions for courses that could help provide better preparation for high school math and science teachers appear in Appendix 1.4.

1.1.3(d). Preparing Post-Baccalaureates for K-12 Math and Science Teaching

There are several pathways for individuals with bachelor’s degrees to become licensed to teach in New Mexico and to add endorsements to existing licenses.

²⁰ www.aft.org/pubs-reports/american_educator/issues/fall2005/BallF05.pdf

²¹ A capstone course, often offered in the final semester of a student’s major, ties together the many strands studied throughout the major. For future teachers, it provides an opportunity to discuss the connections to the relevant K-12 curriculum and the knowledge they need to facilitate student learning.

Post-baccalaureate Licensure Programs and Additional Endorsements

New Mexico's public teacher preparation universities offer post-baccalaureate programs that lead to licensure. The programs are typically about 30 credit hours and all or part of them may count towards a master's degree, depending upon institutional requirements.

State law allows teachers who have a secondary license to earn an endorsement in math or science by completing a number of credit hours in the subject area. Many teachers come to teaching these subjects in this way, yet there are few programs of study specifically aimed at them. As a result, this pathway has less structure. For example, teachers who are interested in an endorsement in mathematics should be advised to take the standard three-course calculus sequence, a statistics course, and the prerequisites for the capstone course as well as the course itself. On the other hand, currently licensed teachers can also add an endorsement simply by passing the relevant New Mexico Teacher Assessment (NMTA) *Content Knowledge Assessment*.⁶

Alternative Licensure Programs

Individuals with appropriate bachelor's degrees who enroll in a New Mexico Alternative Licensure Program at one of the more than a dozen institutions that offer them may begin teaching immediately with an internship license.²² Appendix 1.1 has information specific to secondary math and science teaching, but similar programs are also available at the elementary level. The Alternative Licensure Programs at the secondary level usually require 18 credit hours and at the elementary level 21 credit hours. There are exceptions for individuals who have taught for at least five years in higher education (see Appendix 1.1).

Master's Degree Programs for Teachers

Teachers who return to the university for an advanced degree and wish to acquire an endorsement in a new content area are not often prepared to pursue graduate-level courses in mathematics and science because their prior undergraduate education may not have adequately covered current requirements. These teachers often need to take the same level of coursework the pre-service undergraduates, with the same depth and coherence, but the needs of these teachers are different. Faculty from arts and sciences as well as the college of education should work together to develop an appropriate course of study for teachers pursuing a master's degree as part of their professional preparation. The potential of replicating the University of Texas UTeach program in New Mexico is one avenue to be evaluated. This would require extensive re-tooling of most master's programs in New Mexico and a significant monetary investment. There may also be other interesting approaches, in other states or abroad, that should be examined.

1.2. Findings and Recommendations

Actions taken, or proposed, in response to the recommendations below are discussed in Section 1.3. Connections to the *Strategic Action Plan* are given in Appendix 1.5.

Finding 1.1. Unless action is taken, New Mexico will soon be facing a serious shortage of high school math and science teachers. The situation is most critical in math, where the addition of a required fourth year course for high school graduation will substantially aggravate an already tenuous situation. In both math and science, New Mexico is not graduating enough teachers each year to account for normal attrition.

²² www.teachnm.org/new-teachers/alternative-licensure-options.html

New Mexico Math and Science Advisory Council

Recommendation 1.1: Revise teacher education programs and create a system of incentives that will attract more New Mexico college and university students to K-12 math and science teaching careers. Mount an aggressive effort to recruit high school teachers from out of state (e.g. from *Teach for America*³ and *Troops to Teachers*⁴ programs), from the ranks of retired teachers in New Mexico, and via the instigation of a program to attract STEM professionals into the teaching ranks (see Recommendation 5.2).

Finding 1.2. More must be done to equip New Mexico’s K-8 math and science teachers with the content knowledge, pedagogical skill, confidence and enthusiasm necessary to teach these subjects effectively. This is a critical issue, as many student attitudes toward math and science are formed in elementary school years.

Recommendation 1.2(a): Increase the general education licensure requirement in math content from six to nine credit hours for elementary level teachers (see Section 1.3)

Recommendation 1.2(b): Include engaging problem-solving, inquiry-based math and science content and pedagogy in teacher preparation curricula. This could be aided via the additional involvement of university academic math and science faculty and New Mexico’s STEM professionals (see Recommendations 1.4 and 5.3).

Recommendation 1.2(c): Convene a task force with state-wide representation to redesign entry-level math and science content competencies for pre-service elementary, middle, and high school teachers (see Section 1.3).

Recommendation 1.2(d): Enhance greatly, and make mandatory, a program of continuous professional learning for in-service K-12 teachers and administrators (see Recommendations 2.1(a)-(c)).

Recommendation 1.2(e): Create a special math, or math methods, course for early childhood education programs (birth to grade 3 licensure programs) that focuses on what research teaches us about early number acquisition.

Finding 1.3. Activities in other states (e.g. *UTeach* at the University of Texas, or *1,000 Teachers, 1,000,000 Minds* in California) are demonstrating some success in attracting exceptional undergraduates into the grades 7-12 teaching ranks.

Recommendation 1.3: Study programs from other states and countries to determine if suitably-modified versions could be effectively employed in New Mexico for preparing high school math and science teachers. Make grants available to institutions of higher education to study and possibly implement such a program.

Finding 1.4. Developing a state-wide plan will aid in implementing the above recommendations.

Recommendation 1.4: Convene a statewide conference, jointly sponsored by the Governor and the State Legislature, to develop a statewide implementation plan for improving K-12 math and science teacher education in New Mexico. Include consideration of additional “masters for teachers” programs (see Recommendation 2.1(d)), and the possibility of utilizing STEM professionals (see Recommendation 5.3).

Finding 1.5. MSAC members, and others, have concerns about the efficacy of our current instructional programs for prospective teachers in the areas of math and science. Institutions of

Higher Education (IHEs) need to offer math and science courses that will help prospective teachers gain the kind of deep mathematical and scientific knowledge needed to teach effectively, and to help them see the connections between their own learning in math and science and the work that they will do as teachers. Cooperation and collaboration between departments, colleges, IHEs and K-12 schools in this endeavor is critical for success. Effective pre-service teacher preparation is an issue for the whole K-20 system, and should be addressed as such.

Recommendation 1.5. MSAC strongly encourages all IHEs in New Mexico to develop and use common assessments for their teacher preparation courses in math and science. These common assessments should be developed or selected through a collaborative process that involves both the IHEs and the public school system. These assessments should be used to evaluate whether New Mexico teachers are being prepared with the kind of deep mathematical and scientific knowledge needed to teach K-12 students. The assessments should measure basic content knowledge as well as “pedagogical content knowledge” (the content-based knowledge that is specialized for teaching). Incentives should be developed for faculty, teachers, and institutions who work with each other on course and program improvement initiatives.

1.3. Implementation Plan and Status

For 2009, the Implementation Plan focused on a subset of the above recommendations.

For Recommendation 1.1, MSAC recommended starting a multi-year incentivized effort to attract and prepare more high school math and science teachers. It assumed:

- Targets of 60 math and 30 science teachers graduating each year (90 total), and set targeted numbers for different areas of science.
- That each future teacher requires four years to complete their degree. The program would begin with 90 first-year students. In year two, 180 first- and second-year students, etc. When fully operational, 360 pre-service teachers would be in the program at once.
- That all students enrolled in this program would commit to teaching in STEM disciplines in New Mexico for five years after graduation.
- That if New Mexico were not experiencing severe budget difficulties of its own, perhaps teachers could be recruited from states experiencing teacher layoffs.

MSAC suggested an appropriation for this recommendation that included funding for scholarships, learning materials and summer professional learning programs. The funding for this effort was not available.

For Recommendation 1.2(a), the State Legislature responded (via House Bill HB322, 2009) by increasing the general education licensure requirement in math content from six to nine credit hours for elementary level teachers. The requirement went into effect for students entering institutions of higher education in the Fall, 2009 semester.

For Recommendation 1.2(c), a redesign of the entry-level math content competencies for pre-service elementary, middle, and high school teachers began in Fall, 2009.

For Recommendation 1.2(d), funds were provided (House Bill HB2) for continuation of the Summer Reading, Math and Science Institutes (see Recommendation 2.1(a)-(c)).

New Mexico Math and Science Advisory Council

For Recommendation 1.4, MSAC recommended that a state-wide conference, jointly sponsored by the Governor and the State Legislature, be convened to develop the implementation plan for improving K-12 math and science teacher preparation in New Mexico.

A conference very much along these lines, “On the Road to 2012: Transforming K-12 Math and Science Teaching and Learning in New Mexico,” was the LANL Foundation’s 12th Annual Conference on Education (November 10, 2009). It was jointly sponsored by the LANL Foundation²³ and Innovate-Educate New Mexico²⁴ and was oriented along the lines suggested in this recommendation. It was the first large-scale state-wide conversation on the issues raised by *New Mexico Project 2012*.

For 2010, MSAC proposes:

For Recommendation 1.3 (that a series of meetings be convened to study the feasibility of implementing successful teacher preparation programs from other states and countries here in New Mexico): MSAC will define the scope of this study during 2009-10.

²³ www.lanlfoundation.org

²⁴ <http://innovate-educatenm.org/home>

Appendix 1.1. Pathways to Teaching in New Mexico – A Second Career for Those with a Degree via an Alternative Licensure Program²⁵

If you have five years of post-secondary teaching experience, follow these steps:

- 1) Apply for an Internship License from the Public Education Department
- 2) Get a teaching job with a district or charter school
- 3) Complete one year of successful teaching
- 4) Pass three New Mexico Teachers Assessments⁶ and take one course on the teaching of reading
- 5) Demonstrate department-approved competencies for issuance of a Level II License (\$45,000 minimum salary for the second year)

Note: Only one course, on the teaching of reading, is necessary

If you have six years of post-secondary teaching experience, follow these steps:

- 1) Apply for an Internship License from the Public Education Department
- 2) Get a teaching job with a district or charter school
- 3) Complete one year of successful teaching
- 4) Pass three New Mexico Teachers Assessments⁶ and take one course on the teaching of reading
- 5) Demonstrate department-approved competencies for issuance of a Level III License (\$50,000 minimum salary for the second year)

Note: Only one course, on the teaching of reading, is necessary

If you do not have at least five years of post-secondary teaching experience, these three avenues are available.

1. The Fast-track Alternative Licensure Program

- 1) Enroll in an Alternative Licensure Program²² and receive an Internship License (currently offered at more than a dozen colleges and universities).
- 2) Get a teaching job with a district or charter school
- 3) For a license for teaching in high school, compete the 18-credit Alternative Licensure Program and pass three New Mexico Teachers Assessments⁶

2. Alternative Licensure Portfolio Pathway²²

- 1) Complete a portfolio that demonstrates to the reviewers of your online portfolio submission how you meet the requirements for a Level I license
- 2) Pass three credits of reading courses
- 3) Pass three New Mexico Teachers Assessments⁶
- 4) Get a teaching job with a district or charter school

3. Complete a Post-Bachelor's Licensure Program

Available at many universities.²² Most of these programs offer courses that lead to both a teaching license and a master's degree.

²⁵ www.teachnm.org

Appendix 1.2. Course Suggestions for Elementary Math and Science Teachers

Elementary Mathematics Courses

The National Council of Teachers of Mathematics (NCTM) *Curriculum Focal Points*²⁶ identifies three key learning goals for each K-8 grade level. These focal points should help determine the core material covered in mathematics courses for pre-service teachers.

Developing an understanding of and fluency with numbers is the core goal of K-5 mathematics. In addition, children must gain a solid foundation in basic geometric concepts. Thus, pre-service elementary teachers should study the structure of the rational number system, the place-value structure of our numeration system, and foundational concepts in geometry and measurement.

Because there are both mathematical concepts and attitudes about doing mathematics that will not be fully developed in a single semester course, certain mathematical themes should be treated throughout pre-service K-5 teachers' mathematical coursework. Many of these topics are properly considered topics of the middle school curriculum, but in order for teachers' mathematical knowledge to have *longitudinal coherence*, they must have lots of opportunities to think about how K-5 topics mature in higher grades. The concept of ratio is a central example of this. Children skip-count in kindergarten; it is important for kindergarten teachers to know that skip counting blooms as multiplication and forms the roots for ratios. Since ratios are one of the core concepts of the middle school curriculum, elementary school teachers should have lots of opportunity to make connections between this concept and the other core topics of the K-5 curriculum. Global concepts that should be revisited throughout the elementary mathematics sequence include ratios and proportions, patterns and algebraic concepts.

In addition, prospective teachers must be provided opportunities for problem solving and an emphasis on mathematical representation, reasoning and explanation throughout their courses. Pre-service teachers also need to see how mathematics can help them and their students solve real-world problems. While both ratios and algebraic concepts and use of symbolic notation should be incorporated throughout the first two courses as "global" topics, it should be made a specific focus in a third course that elementary school teachers might take. Furthermore, while probability and data analysis are not indicated as core focal points until grade 8, they are mentioned in every grade's "Connections to the Focal Points"²⁷ and are included in the New Mexico state *Standards* starting in kindergarten. Thus, a third mathematics course for elementary teachers should also address probability and data. This is especially appropriate because ratios should have a greater emphasis in this course as well, and connections between ratios and probability are natural.

²⁶ www.nctm.org/focalpoints

²⁷ *Curriculum Focal Points* presents "Connections to the Focal Points" at each grade level. These are ways in which a grade level's focal points can support learning in relation to *Standards* that are not focal points at that grade level.

Elementary Science Courses

A primary recommendation of the NSTA regarding elementary science teacher preparation is that both teacher preparation and professional learning provide experiences that will enable teachers to (1) use hands-on activities to promote development of scientific and critical thinking skills, (2) select content and methods appropriate for their students, and (3) design of classroom environments that promote positive attitudes toward science and technology. Inquiry-based, integrated science courses designed specifically for pre-service teachers have proven effective and should be the first choice for pre-service programs. The alternative is that coursework be carefully selected from the options offered by science departments, though it may well require specific pre-requisites in mathematics and other science coursework.

Strategies: Pre-service teachers should experience a variety of hands-on activities that cover a range of instructional strategies including, but not limited to, classroom demonstrations, independent projects, group projects, guided inquiry and free inquiry. Within these experiences, teachers need support in developing basic skills such as making and recording observations, recognizing patterns, collecting data and making and interpreting graphs and other visual representations of data (technical diagrams, maps, etc.).

Course Content: This should mostly be driven by state and national science education standards and benchmarks covering the major fundamental theories and principles of the physical and biological sciences. Where possible, content in classes for pre-service teachers should emphasize the integrated nature of the science disciplines they will be teaching. Also, knowledge of the scientific process, the nature of science and practices involved in scientific thinking need special emphasis. These aspects are embodied in developing scientific inquiry skills and attaining a working knowledge of scientific literacy. The NSTA has stated that “the ability to engage in effective inquiry using scientifically defensible methods is considered a hallmark of scientific literacy.”²⁸

Pre-service Student Attitudes: A fundamental concern for teaching science (and math) to pre-service elementary teachers is the frequent negative attitudes about science (and math) that many of them bring to the classroom. Coupled with the relatively low scientific skill levels of many of these students, negative attitudes represent a significant barrier to preparing these individuals to be effective science teachers. Instructors for pre-service science courses should model both positive attitudes about science and the process of science, including the impact of science on society. Also, specific details about the fundamental goals of science and how science can answer some questions and not others may be effective in promoting healthier attitudes towards learning and teaching science.

²⁸ www.nsta.org/pdfs/NSTASTandards2003.pdf

Appendix 1.3. Course Suggestions for Middle School Math and Science Teachers

Middle Grade Mathematics Courses

Teaching mathematics in middle grades requires preparation different from, not simply less than, preparation for teaching high school mathematics, and certainly requires more depth than that needed by teachers of earlier grades. Two types of courses should be included in preparing middle grade math teachers. First, courses must be designed that will provide a deep understanding of the mathematics to be taught. Some of this coursework could overlap with coursework for K-4 teachers, particularly that concerning fundamental ideas (such as place value) that extend from whole numbers to decimals.

Second, courses are needed that will strengthen these prospective teachers' knowledge of mathematics and broaden their understanding of the mathematical connections between one educational level and the next, between elementary and middle grades, and between middle grades and high school. This second type of coursework would require at least a pre-calculus or college algebra background. One semester of calculus also should be part of this second group of courses, especially one that focuses on concepts and applications.

Number theory and discrete mathematics can offer teachers an opportunity to explore in depth many of the topics they will teach. A history of mathematics course can provide middle grades teachers with an understanding of the background and historical development of many topics in the middle grades curriculum. A mathematical modeling course, depending on the level and substance of the course, can provide prospective teachers with understanding of the ways in which mathematics can be applied. If the prospective teachers are likely to teach algebra, coursework in linear algebra and modern algebra would be appropriate. If, in addition, the teachers might be expected to teach a full-year course in geometry, then they should have the same geometry coursework as prospective secondary teachers.

Middle Grade Science Courses

In parallel with the above, teaching middle grades science requires preparation different from, not simply less than, preparation for teaching high school science and certainly requires more depth than that needed by teachers of earlier grades. Courses must lead prospective teachers to develop a deep understanding of the specific science discipline they will be teaching. An NSTA focus²⁸ for this grade level is the recognition that middle school students attitudes and interest toward science are at a pivotal point; many national assessments show a significant decrease in science scores in middle school that continue to decrease into high school. To address this trend, teacher preparation should utilize inquiry-based approaches to stimulate and maintain student interest. Where possible, the connection between science classroom content and activities should show the impact and importance of science and technology on society, including understanding and addressing important local, state and national issues such as water resources, energy and global climate change.

Some of this coursework could overlap with coursework for K-5 teachers, particularly that concerning fundamental concepts of physical and life science and the nature of scientific thinking and process. Specifics of these programs are addressed in the section on elementary science above. However, the necessary depth of knowledge to teach middle school, and mandates for highly qualified teachers, require pre-service teachers to complete additional courses. These additional classes can take on a variety of modes, including standard lab/lecture courses offered by university science departments, summer courses, online courses or research experiences that are becoming more available to middle and high school science teachers.

Appendix 1.4. Course Suggestions for High School Math and Science Teachers

High School Mathematics Courses

The education of prospective high school mathematics teachers should help them develop:

- A deep understanding of the fundamental mathematical ideas in grades 9-12 curricula and strong technical skills for application of those ideas.
- Knowledge of the mathematical understandings and skills that students acquire in their elementary and middle school experiences, and how they affect learning in high school.
- Knowledge of the mathematics that students are likely to encounter when they leave high school for collegiate study, vocational training or employment.
- Mathematical maturity and attitudes that will enable and encourage continued growth of knowledge in the subject and its teaching.

The CBMS report⁹ recommends two main ways that mathematics departments can attain these goals. First, core mathematics major courses can be redesigned to help future teachers make insightful connections between the advanced mathematics they are learning and the high school mathematics they will be teaching. Second, mathematics departments can support the design and development of a capstone course sequence²¹ for teachers in which conceptual difficulties, as well as fundamental ideas and techniques of high school mathematics, are examined from an advanced standpoint. Such a capstone sequence would be most effectively taught through a collaboration of faculty with primary expertise in mathematics and faculty with primary expertise in mathematics education and experience in high school teaching.

At the University of New Mexico, the mathematics education concentration for the bachelor's in mathematics currently requires students to take the traditional calculus sequence, calculus for teachers, history of mathematics, college geometry, a course in problem solving, discrete mathematics, linear algebra, abstract algebra, statistics and a one-semester capstone course for secondary mathematics teachers. Calculus for teachers, problem solving, and the capstone course are all designed to help teachers make connections between the traditional undergraduate-level content they learn and the mathematics they will teach as high school teachers.

High School Science Courses

The education of prospective high school science teachers should help them develop:

- A deep understanding of the fundamental principles and applications in grades 9-12 curricula.
- A deep knowledge of laboratory science sufficient to select, equip and teach laboratory exercises safely.
- Knowledge of the science concepts taught at the middle school level and how they connect to learning in high school.

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- Knowledge of the science concepts that students are likely to encounter when they leave high school for collegiate study, vocational training or employment.
- Scientific and mathematical maturity and attitudes that will enable and encourage continued growth of knowledge in the subject and its teaching.

Currently, because science endorsement requirements are for general science, most undergraduates in New Mexico planning to become high school science teachers work on a degree in Secondary Education that usually includes over 50 credit hours of science content courses, with one discipline serving as an emphasis area. Biology is by far the most common emphasis area. There are only rare examples of science content courses that are specifically designed for future high school science teachers. One example of such a capstone course is in the Biology Department at UNM. It is offered irregularly with special funding from an NSF Noyce Grant.²⁹

²⁹ NSF Robert Noyce Teacher Scholarship Program. www.nsf.gov/funding/pgm_summ.jsp?pims_id=5733

Appendix 1.5. Links to the *Strategic Action Plan*

The *Plan* lists two measures for its Goal 1 (“Increase student interest, participation and achievement in math and science”) which are relevant to improving the quality of teacher preparation and the numbers of teachers prepared each year:

- 1.d. Evidence of improved teacher content knowledge.
Measure: Improved performance on math and science sections of the New Mexico Teacher Assessments.⁶
- 1.e. Evidence in the increase of fully-licensed math and science teachers.
Measure: Increase by 5% per year the number of fully-licensed secondary math and science teachers.

This chapter focuses on implementing the Actions from Strategy 1.2 (“Improve the initial pre-service preparation of math and science educators”) of Goal 1. The Actions to be implemented, and their corresponding measures, are to:

- 1.2.1 Develop a common vision of the content knowledge and pedagogy that pre-service teachers need in order to be effective teachers of math and science.
Measure: This work is in progress. A meeting to develop such a vision for math was held in Taos in May, 2007. A report is available.³⁰
- 1.2.2 Make recommendations for how to revise the required math and science courses so that they lead to the development of a more profound understanding of fundamental math and science concepts.
Measure: This is addressed comprehensively in Section 1.1.3 above, but may be modified by receipt of input from the New Mexico education community.
- 1.2.3 Incorporate the *Standards* and K-12 curricula that encourage inquiry-based problem solving into teacher preparation programs.
Measure: This will be certified when syllabi for math and science method courses given at New Mexico’s teacher preparation institutions indicate the incorporation of standards and inquiry-based problem solving K-12 curricula.
- 1.2.4 Given Actions 1.2.1 to 1.2.3, revise the New Mexico *Competencies for Entry-Level Math and Science Teachers* and the math and science sections of the *New Mexico Teacher Assessments*.
Measure: This will be certified by publication of the appropriate new teacher competencies in the *New Mexico Administrative Code*.
- 1.2.5 Improve recruitment and retention of highly-qualified math and science pre-service teachers with diverse backgrounds.
Measure: Recruitment statistics show significant improvement in this area.

The task of improving pre-service teacher education is also linked to other parts of the *Plan*: (e.g. Strategies 1.1, 1.3, 1.4, 2.1, 2.3, 2.4, 2.5 and 3.1, and Action 1.2.6)

³⁰ www.math.unm.edu/lameta/taos/RecommendationsDraft2.pdf