

Background

The following report is the result of a series of discussions involving more than 45 university faculty and deans, drawn from schools of arts and science and schools of education from the fifteen universities which are partners in the Philadelphia Math + Science Coalition. The discussions have attempted to define the knowledge, skills and dispositions that undergraduate math and science majors should have in order to become certified math and science teachers. The schools involved are Arcadia University, Bryn Mawr College, Chestnut Hill College, Cheyney University, Drexel University, Eastern University, Holy Family University, LaSalle University, St. Joseph's University, Temple University, University of Pennsylvania, University of the Sciences, Villanova University, West Chester University and Widener University.

The process that led to this report began in 2007 with a small working group, chaired by Len Soroka and based on Goal 3 of the Coalition Strategic Plan, which stated *“Enhance current teacher pre-service programs and, as needed, create new programs designed to prepare future math and science teachers to teach in Philadelphia, in particular on the secondary level.”* The group examined the course requirements for teacher preparation programs at seven partner universities. It was apparent that course sequences alone revealed little about the way in which math and science teachers are prepared. Since math and science teachers are prepared by both schools of education and by faculty in the disciplines, the group planned a series of meetings involving deans and faculty from arts and science and from education.

The first of these meetings was a symposium held at Arcadia University in late 2008. Teams made up of arts and science and education faculty attended and focused on how the faculty in these departments could collaborate to better prepare math and science candidates. The agenda also included a keynote address by Dr. Michael Klymkowsky, PI of the CU Teach program at the University of Colorado, Boulder. Partner universities made commitments to improve collaboration between discipline faculty and education faculty in the preparation of math and science teachers. During 2009 and 2010, faculty from the fifteen partner schools have met to construct a profile of an effective math and science teaching candidate.

The discussions have been structured around three main areas: content, pedagogy and personal characteristics of math and science teaching candidates. Outcomes of the discussion have taken the form of the desirable skills, knowledge and dispositions of undergraduate math and science teaching candidates. What should the graduates know and be able to do when they graduate from our universities? Expecting that many of these candidates will teach in the School District of Philadelphia, a sub-text for the discussions has been ways in which candidates can be prepared not just to teach math and science effectively, but to do so in urban classrooms. The faculty also began to translate these skills into the teacher education program components needed in order to graduate candidates with the required skills and to determine how to assess whether candidates actually have acquired the required skills.

The outcomes of these discussions comprise a series of recommendations to be considered and hopefully enacted at partner universities.

Recommendations

Principle 1: The ideal environment in which a math and science teacher education program takes place can best be characterized as a “community of learners.” In this community teacher candidates work actively with colleagues, instructors and a rich variety of other education resources as they begin a career-long process of acquiring and refining their content knowledge, research and pedagogical skills specific to math and science.

Recommendation 1:

*Foster and require collaboration and continuous communication between instructors in math and science disciplines and those in education in order to help candidates to **integrate content knowledge and pedagogy.***

Recommendation 2: *The math and science education curriculum should require and enable students to **develop deep understandings of how math and science can be used to solve problems and answer questions using essential content and pedagogical/experimental methods.***

Principle 2: Offerings in education should be organized around essential educational principles as well as unifying scientific and mathematical concepts and should be firmly anchored in the growing body of research, standards and practice related to how students learn math and science and what strategies are effective in increasing student achievement in math and science.

Recommendation 3: *Math and science teacher preparation should be based on the growing research on how students learn. Candidates should be able to **demonstrate an understanding of students’ needs, community context and community resources** by:*

- *Identifying learning styles and employing a variety of pedagogical methods to take advantage of the differences in a wide variety of students in Philadelphia classrooms.*
- *Being able to ask questions from multiple cognitive levels*
- *Being able to diagnose student conceptions – locate students ideas on conceptual trajectory and know how to adjust teaching accordingly*
- *Having content specific pedagogical content knowledge*
- *Presenting content so it is accessible to students – selecting good tasks for students*

Recommendation 4: *The scope of content knowledge is specified by many professional organizations like the National Council of Teachers of Mathematics and the National Science Teachers Association, and these and other recommendations should be studied and adopted. However, **content knowledge for teachers in the disciplines should be anchored to big ideas in math and science and how these ideas are interconnected.** In addition, candidates should also master the process skills in math and science. Examples of these include modeling, problem-solving strategies, pattern recognition, generalization and adaptive reasoning.*

Recommendation 5: *Throughout their preparation math and science candidates should be trained in using **inquiry-based or problem-based approaches to learning.** Curricula should be planned and courses should be taught using these approaches. Furthermore, the skills needed to teach children using these approaches should be one of the central learnings in the teacher preparation program. Among these skills are:*

- *Act as a guide for student research*
- *Treat students as apprentice scientists/mathematicians who are refining their craft rather than treating them as needing to be “taught” or having gaps to be filled in.*
- *Be proficient at posing problems in a way that encourages students to develop as independent problem solvers*
- *Provide field experiences and teach lab skills*
- *Demonstrate the ability to source/critique/develop effective inquiry activities (constructivism)*
- *Demonstrate an understanding of the importance of sequencing of activities and how to sequence them properly*

Principle 3: The teacher preparation program that trains teachers for the School District of Philadelphia should intentionally prepare teachers for urban classrooms. Programs should recognize the diverse needs of students in Philadelphia and should also emphasize the need to recruit teachers of color to work in Philadelphia classrooms. College or university departments should continuously seek partnerships and

other working relationships with schools in Philadelphia. Experienced math and science teachers in Philadelphia should be encouraged to inform the work of the university teacher preparation program, as advisors, mentors, cooperating teachers and instructors in the university. The universities should also provide opportunities for teachers to enroll in advanced courses.

Recommendation 6: *Candidates should be expected to master a variety of teaching methods appropriate for urban environments, including employing laboratory experimentation and data collection, and adapting these skills through cooperative activities to particular students, content and context.*

Recommendation 7: *Candidates should be able to demonstrate a variety of classroom management skills that are required to be effective in urban classrooms.*

Principle 4: Candidates should also demonstrate skills related to assessment of student achievement. These skills should include using student data to inform curriculum and teaching, assessing students formatively and summatively as well as preparing students in an appropriate way for high-stakes testing.

Recommendation 8: *Candidates should be trained in the use of multiple assessment methods, including analysis of assessment data, authentic assessment, formative and summative assessments and should be able to modify existing instruction to reflect students learning needs.*

Principle 5: In addition to high quality university classroom experiences, teacher candidates should participate in fieldwork in Philadelphia schools early in their studies. These field experiences, as well as later student teaching should be carefully integrated with students' university course work. Of high importance here are an understanding of the diverse cultural context in which learning occurs, classroom management and disciplinary skills and the ability to differentiate instruction for a diverse student population.

Recommendation 9: *Field experiences should include observing, collecting and recording data, interacting informally and formally with K-12 students in classes and preparing and teaching lessons of increasing complexity. Students should be required to reflect on these experiences deliberately and systematically both in writing and in discussion with colleagues and instructors. Student teachers should be placed with experienced math or science teachers, who have been trained to work with student teachers in the program.*

Principle 6: In current secondary classrooms technology plays an increasingly important role. However, many teachers are not skilled at the appropriate use of educational technology.

Recommendation 10: *Integrate throughout the pre-service curriculum training in technology that supports instructional goals.*

Principle 7: What is needed for math and science teachers is not only the content needed for the courses they will be teaching, but also the professional reflective practice of continually asking about important ideas here, looking at students' thinking and asking what are the big ideas at play for a given learning situation and how do they articulate/relate and thinking about the multiple approaches to problems.

Recommendation 11: *Pre-service programs should develop in candidates an understanding of and commitment to professional practices of mathematical and scientific problem solving for teaching, assessing/diagnosing student thinking, and designing effective instruction/interventions.*

Principle 8: Programs should provide candidates with experiences in research methods and should include authentic research experiences in their academic field as well as action research related to their teaching experiences. An over-arching goal will be to require teacher candidates to develop a sense of how scientists and mathematicians think about the world and go about their work. Candidates should develop the intellectual curiosity, the skills, habits of mind and attitudes of scientists and mathematicians. These attitudes should also include creativity, making conceptual connections both within and between disciplines, intellectual honesty, respect for experimental evidence, and respect for differences in both people and ideas.

Recommendation12: *Education faculty should involve, where appropriate, their students in science and math education research, and faculty in the disciplines should provide appropriate research experiences that develop the habits of mind displayed by practicing mathematicians and scientists. This is another area of preparation that requires close collaboration between education and arts and science faculty.*

Candidates will demonstrate these research-related in a variety of ways including written lesson plans, laboratory activities, project based assignments and units, supervised classroom teaching and recorded teaching. Each candidate will develop and maintain an electronic portfolio addressing these professional skills.

The university should make this list of skills an intentional part of teacher preparation courses. Some skills should be taught in multiple courses throughout a candidate's preparation. Other skills may require the intensive experience of a single course or research project

Principle 9: The university should actively and consistently recruit students who have an interest in either scientific or quantitative literacy to enter the secondary math and science teacher preparation program by a variety of means. The recruitment process should be systematic and multi-layered in order to encourage multiple entry points into the teacher preparation program. Recruiting teachers of color should be a high priority.

Recommendation 13: *Develop incentives for math and science majors to become certified and remain in teaching, e.g., internships, job guarantee, support during induction into the first year of teaching. Couple these incentives with a rigorous and rich, welcoming curriculum in both science and mathematics departments and education departments.*

Principle 10: Research and experience shows that support for candidates during their first year of teaching often determines whether the candidate is successful as a teacher.

Recommendation 14: *Universities should work with the School District and other partners to provide continuing support for their math and science teaching graduates during at least their first year of teaching.*

The first fourteen recommendations are the result of the series of meetings of the faculty/department chairs group, including a meeting on June 3, 2010. At the June 3 meeting the faculty made an additional recommendation regarding collaboration.

Principle 11: The schools which are partners with the Coalition should increase their level of collaboration in preparing math and science candidates. Each of the partner schools has had success in one or more of the areas discussed in this report. And each of the partner schools offers unique resources for the preparation of math and science candidates.

Recommendation 15: *The number of math and science preparation candidates at any given partner school campus is relatively small. In order to maximize the use of these resources, partner universities should discuss ways of making their unique program offerings, currently available only to students at a given school, available to students from other schools. Non-credit offering should be considered as a first step.*