THE STATE OF AFFAIRS

Impact and Implications of STEM Teacher Education at Two-Year Colleges

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A Report from The Meeting Of The Minds Symposium
National Science Foundation ♦♦ November 19, 2008

Laurie A. Fathe, Ph.D.
Higher Education Consultant

Judy Kasabian, Ph.D.
El Camino Community College

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♦♦ INTRODUCTION ♦♦

The Authors' Perspective On STEM Teacher Preparation Efforts At Two-Year Colleges

The Science, Technology, Engineering, and Mathematics (STEM) preparation of the next generation of K-12 teachers is a complex and collaborative endeavor. Success requires coordinated effort from school districts, colleges and universities, local, state and federal agencies, and professional organizations. Two-year colleges have a unique and important role to play in this process. They must know the issues, understand the ways in which they can contribute, design programs that are effective, establish their place in the educational community, and make their voices heard in the conversations that take place regarding teacher preparation. The Meeting Of The Minds project joins STEM educators from two-year colleges and leaders from relevant professional organizations to examine how these institutions can make vital contributions to the STEM preparation of prospective teachers. This document provides a historical and contemporary view of STEM teacher preparation at the two-year college level, describes attributes of successful projects, articulates the challenges that two-year colleges face in this endeavor, and puts forth recommendations to help STEM teacher preparation continue to grow and thrive. We hope that this document will contribute to the development and implementation of exemplary projects in STEM teacher preparation at two-year institutions, increase the collaboration among all members of society around this enterprise, bring visibility to these important issues, and ultimately improve the STEM education of K-12 students across the United States.

Today I am announcing a renewed commitment to education in mathematics and science. Through this commitment, American students will move from the middle to the top of the pack in science and math over the next decade. For we know that the nation that out-educates us today – will out-compete us tomorrow.

We cannot start soon enough. We know that the quality of math and science teachers is the most influential single factor in determining whether a student will succeed or fail in these subjects.

••President Obama
The National Academy of Sciences
April 27, 2009

♦♦ THE CONTEXT ♦♦

A Historical And Contemporary Look At Two-Year Colleges' Role In STEM Teacher Preparation In 2009

During the 1990s, the National Science Foundation (NSF) mounted a concerted effort to improve the science and mathematics knowledge of K-12 students by enhancing Science, Technology, Engineering, and Mathematics (STEM) teacher preparation in two-year and four-year colleges and universities. Through programs such as their Collaboratives for Excellence in Teacher Preparation (CETP), the Mathematics and Science Partnership (MSP), and the teacher preparation track of the Advanced Technological Education (ATE) program, National Science Foundation made significant investments to better prepare tomorrow's teachers to educate students in STEM disciplines, which continue to be critical to the economic and technological future of the United States. The projects funded under these programs stretched the length and breadth of the country. The projects affected tens of thousands of prospective teachers, giving them enhanced STEM education, early classroom experiences, mentoring before and after they entered their first teaching positions, and ongoing professional development. The projects also had long term impacts on the host institutions, enhancing the teaching of college faculty members, impacting the culture of the institution, and changing the structure of STEM teacher preparation at a significant number of two- and four-year institutions.

While all institutions that participated in the NSF projects were affected to some degree, probably the greatest impact was realized at two-year colleges. In the early 1990s at many two-year institutions, teacher preparation was not integrated into the curriculum, or in some cases, even recognized as being a mission or responsibility of the institution. By the late 1990s, many two-year colleges had established programs in teacher preparation and had begun to take ownership and responsibility for this important endeavor. The 1998 National Science Foundation document, *Investing in Tomorrow's Teachers: The Integral Role of Two-Year Colleges in the Science and Mathematics Preparation of Teachers*, captured the thoughts, reflections and recommendations of leaders of the teacher preparation movement at two-year colleges and professional organizations. Specifically, this publication documented successful two-year college teacher preparation efforts and provided specific recommendations for two-year colleges to better meet the national need for well-prepared teachers of science, mathematics and technology. The document, known colloquially as the "Blue Book", became the beacon for two-year colleges seeking to build or improve their STEM component of teacher preparation.

In the decade since *Investing in Tomorrow's Teachers: The Integral Role of Two-Year Colleges in the Science and Mathematics Preparation of Teachers* was published, STEM preparation for pre-service teachers at two-year colleges has continued to expand and improve. One signature program in this effort, funded by the National Science Foundation and organized through Phi Theta Kappa, the community college honorary society, was "Preparing Tomorrow's Science and Mathematics Teachers: The Community College Response". This multi-year project assisted 35 two-year institutions in developing and implementing effective STEM teacher preparation programs and practices, under the guidance and mentorship of faculty from two-year and four-year institutions which had built their own successful programs. Many other smaller, yet equally successful STEM teacher education programs, were developed at two-year colleges through their own Advanced Technological Education grants. Still, in 2009, much remains to be done.

The education community faces many of the same challenges in 2009 it has grappled with over the past few decades. Students from low socio-economic backgrounds are often unprepared to successfully navigate college, may have less academic success than their more affluent classmates, leave college prior to graduation, and are less likely to complete post-secondary degrees. Meager and sometimes woefully inadequate funding impedes the ability of K-16 schools to provide personalized attention and special services for students with the greatest need as well as for those with the greatest potential. Aging infrastructure, especially in urban areas, disheartens students, teachers, and parents, and redirects limited school funds to maintenance and replacement. The need for qualified skillful teachers, particularly in the STEM disciplines, is at least as great today as it was a decade ago.

Many would say that the weak economy of 2009 is the biggest challenge facing both K-12 and higher education today. Certainly the reduced funding levels that will be the reality for the next few years will constrain the ability of educational providers to maintain their current level of service, let alone implement new programs and practices. While the technological pace in the world continues to accelerate, it is likely to decelerate in classrooms. Infrastructure renewal will slow to a crawl and day to day supplies will be rationed at greater rates than ever before. New teacher support and mentoring, the ongoing professional development that keeps teachers in touch with the latest knowledge and practices about teaching and learning, will certainly be reduced as funding levels decline.

However, the toughest challenges go far beyond simple dollars and cents. Additional dollars will not stem the tide of retirements of aging Baby Boomers, reduce the number of K-12 second-language learners, or change the fact that people need to be facile in mathematics, science, and technology to compete in the ever more global and technological economy. The No Child Left Behind Act of 2001, which forced dramatic changes in the curriculum, teacher certification, and core operations of many K-12 public schools will likely be modified under a new federal administration, but the desire and urgent need on the part of both the government and the public for reliable and valid indicators of student achievement will not disappear. Teachers and administrators will need ongoing training to meet the increasing demands for accountability.

One well-respected measure of achievement for K-12 students is the Trends in International Mathematics and Science (TIMSS) study. The 2008 TIMSS results for the United States show that poorer students continue to lag more affluent students in science and mathematics achievement at both the fourth grade and eighth grade levels. Similarly, African American and Hispanic students' performance continues to lag that of their Asian and White counterparts. U.S. students improved their mathematics scores at both the fourth and eighth grade levels. However, their science scores remained essentially unchanged from the previous TIMSS test while scores of students from most other countries improved. The trend of the scores in the TIMSS study is an indicator that the United States is losing ground in a very competitive global market. The TIMSS results underscore the need for K-12 teachers skilled in STEM instruction at both the primary and secondary grades.

Two-year colleges continue to be an essential link in STEM teacher education. More than 20% of all teachers begin their college careers at two-year institutions and nearly half of all teachers complete some of their science or mathematics courses there. The diversity seen in local K-12 classrooms, including ethnic background, socio-economic level, and students' preparation and natural ability, is better represented at the two-year colleges than at their four-year counterparts. Therefore, two-year colleges are the places to look to recruit and train a diverse pool of K-12 teachers. These colleges are commonly the point of entry into higher education for older returning students, and for teacher's aides and preschool teachers wishing to upgrade their knowledge and skills to become K-12 educators. Two-year colleges, at their core, are public serving institutions. Like the K-12 schools, they serve all who come and accurately reflect the demographics of the surrounding community.

STEM faculty at two-year colleges are skilled and knowledgeable educators, as teaching is their primary focus and responsibility. This makes two-year college faculty ideally suited to deliver and assess the STEM content knowledge of the future teachers in their classroom. Class size at two-year colleges is generally small enough to provide students with the attention they need to learn. The smaller class sizes and more personalized instruction give pre-service teachers, particularly prospective elementary school teachers, the chance to learn mathematics and science in an environment that helps them understand the content and overcome any reticence they may have about these traditionally intimidating subjects. In addition to helping future teachers learn the content, this type of instruction provides them with suitable strategies for teaching STEM disciplines.

Two-year colleges have a crucial role to play in the educational foundation and economic advancement of the country, particularly during the current economic downturn and retrenchment of many U.S. businesses. The institutions offer great value to both their students and their states, providing education at a reasonable cost. They are the main point of access to higher education for students of limited means, for those needing substantial remediation, and for older students returning for college degrees. They provide the ongoing workforce development for workers seeking to upgrade their skills or transition into a new career. It is clear that two-year colleges will be critical in the recruitment, training, and on-going professional development of the next generation of STEM professionals and teachers, and must be full partners in this process.

As we near the end of the first decade of the new millennium, it is again time to examine the context in which we work, take stock of our efforts, and share with the greater community those activities, programs, and ideas which have been shown to be effective in preparing the next generation of classroom teachers.

♦♦ THE MEETING OF THE MINDS ♦♦

A Symposium Of STEM Teacher Educators

The Meeting Of The Minds Symposium, held on November 19, 2008 at the National Science Foundation, brought together educational leaders for a working symposium to discuss STEM teacher preparation efforts at two-year colleges. The twenty-two participants included faculty and administrators from 17 two-year colleges from across the country and representatives from professional organizations involved in STEM education. The rich and varied backgrounds and experiences of the participants provided insight and perspective and shaped the content of this publication.

The four key objectives of the Meeting Of The Minds Symposium were:

1. Compile information on highly effective STEM teacher preparation strategies and practices at two-year colleges which could be replicated at other institutions.

2. Discuss and report the ways in which sponsored projects have fostered persistent changes at two-year colleges.

3. Determine ways in which pre-service teachers' content and pedagogical knowledge can be effectively assessed.

4. Generate specific recommendations to improve the quality and quantity of STEM teacher preparation projects at two-year institutions.

Prior to the symposium, participants completed a questionnaire with information about their institution or organization; ways in which projects or organizations have contributed to STEM teacher preparation; ways in which projects have made sustained changes at their institution; types of evidence collected to demonstrate project success and ways in which that evidence has been gathered; and finally what the Meeting Of The Minds participants expected from this symposium. The pre-symposium questionnaire can be found in the appendix. The information the participants submitted was used as a starting point for many of the discussions at the symposium. The following sections of this report reflect the discussions and represent the combined wisdom and insight of the symposium participants.

The challenge of getting more young people into science is not something we can successfully implement in Washington. That falls to you and your colleagues in classrooms all across America.

You need to challenge yourselves and each other to move the curriculum beyond dinosaurs and volcanoes—and I know that many of you already have—but we need to take the best ideas to scale in tough inner-city districts like this one—as well as rural areas that cannot find qualified teachers in every subject.

You need to make inquiry-based science relevant to kids—stimulate their curiosity—connect it with their lives. Together we need to change the national dialogue about science—to prepare our kids to be honestly critical and technically competent.

Science is all about questioning assumptions, testing theories, and analyzing facts. These are basic skills that prepare kids not just for the lab—but also for life. We're doing kids a disservice if we don't teach them how to ask tough and challenging questions.

⬩⬩Arne Duncan, Secretary of Education
Addressing the National Science Teachers Association Conference
March 10, 2009

♦♦ SUCCESSFUL PROJECTS ♦♦

Components Common To Effective Projects

Success in a STEM teacher preparation project is defined as graduating new teachers who have the content knowledge, pedagogical strategies, and other skills essential to become effective classroom teachers. Successful projects in STEM teacher preparation do not happen by chance. They have the right people in the right place at the right time with the right idea. We have observed that these projects start with a grand **vision**, which typically is a big idea that is innovative and new for the organization involved. The vision is then distilled into a set of concrete **goals** which dictate the structure of the project. The next step is **research** into what others have done in the field, and developing a deep understanding of one's institution, faculty, and students. This ensures that the project leaders understand the context of the project. If external funding is needed, investigating a variety of avenues for funding opportunities follows. A clear **action plan** is developed, which serves to guide the project's operation and implementation. Measurable **benchmarks** are then defined, which help leaders monitor the project's progress and make necessary adjustments in plans and processes. **Indicators of success** highlight the project's accomplishments at the institution and in the community.

EFFECTIVE LEADERSHIP

Successful leaders of STEM teacher preparation projects need extensive knowledge and a mindset which allows them to meet the many challenges presented by such projects. All these leaders recognize that successful projects build upon the work of those who came before, and that these projects require consistent and significant amounts of effort and enthusiasm.

Specifically, leaders of successful STEM teacher preparation projects possess the following requisite knowledge and skills:

- Significant knowledge about effective practices in teacher preparation.
- Deep content knowledge and an understanding of effective pedagogical practices in their discipline.
- An understanding of the institution at which they work.
- An understanding of needs and goals of their students.
- How to facilitate project operations.
- How to make their projects visible in the local community and beyond.
- How to assess the project's progress and use the information to make necessary adjustments.
- How to best utilize the knowledge and talent of project staff and participants.

In addition, leaders of successful STEM teacher preparation projects have a certain mindset. We found that these leaders have the following characteristics. They:

- Do their homework and build on prior knowledge and successes.
- Believe students will succeed in their endeavors.
- Ensure that the project's efforts are aligned with the project's goals.
- Continue as life-long learners.
- Build partnerships and coalitions which will further the project.
- Are innovative, enthusiastic, and have a positive attitude.
- Are not afraid to try new things.
- Are ready to implement better ways to achieve project goals.
- Are ready, willing, and able to do whatever work is necessary to bring the project to a successful conclusion.

AREAS OF FOCUS

The descriptions in the pre-symposium questionnaires and the discussions at the symposium revealed that successful projects focus on four common areas – college students, faculty, institutions, and the community. The information below details successful strategies related to each of these four areas.

COLLEGE STUDENTS

Recruitment, Retention, and Advisement

- Recruit extensively in two-year college courses, at college activities, and by using participating students to publicize the program.
- Recruit in local high schools, particularly at college fairs, Future Teachers of America meetings, and at other activities promoting post-secondary education.
- Identify prospective teachers early in their two-year college careers and advice them into appropriate bridge programs for future teachers.
- Ensure that students get effective advising that directs them to the best courses for future teachers and guides them through completing their academic coursework and requirements as smoothly as possible.
- Attract other college students to the program through a variety of activities.
- Use peer learning or tutoring programs as an entrée into teaching for future educators.

Connectedness

- Establish an atmosphere and activities that help students feel connected to the program and the college.
- Inform students that their participation in the program is important and only available at the two-year college. Help students feel that they will always be part of the program both after they transfer and when they become classroom teachers.
- Build strong faculty-student interaction opportunities into the program. Such mentoring relationships ensure that students are well informed and supported during their academic programs and also help students to stay motivated.
- Provide physical space at the college where future teachers can meet with program staff, study, or interact as a group.
- Provide perks for the pre-service teachers, such as snacks, t-shirts, opportunities for field trips, and other special activities. All these efforts build a sense of community and contribute to the retention of future teachers in the program.
- Create learning communities to provide a peer support system and give the participants a sense of belonging to the program and the institution.

Pre-Professional Experiences and Benefits

- Provide opportunities for students to teach others (peer tutoring, mentoring K-12 students, tutoring K-12 students, and/or guest teaching in a K-12 classroom) so that they learn what it is like to be a teacher and to determine if teaching is a suitable profession. Ensure that the program includes a comprehensive teacher training component so that tutors, mentors, and guest teachers are prepared to succeed.
- Build into the program a significant number of hours to observe exemplary classroom teachers as well as the chance to guest teach in a K-12 classroom.
- Teach pre-service teachers how to effectively integrate technology into instruction to enhance learning.
- Provide professional development opportunities for pre-service teachers, such as motivational and educational guest speakers or a Future Teachers Conference.
- Utilize pre-service teachers as ambassadors at local middle and high schools to promote a career in teaching and/or enrollment at the two-year college.
- Provide benefits for prospective teachers in the program. Awards, letters of recommendation, assistance in writing resumes, support in the transfer process to a four-year institution, and public recognition can be provided at minimal cost. If funds permit, consider providing food at events, teaching resources, scholarships, and attendance or presentation opportunities at professional meetings.

FACULTY

Connectedness

- Build collaborations among faculty, staff and administrators within the division or department.
- Build partnerships across disciplines, particularly between STEM and Education faculty, administrators, and staff.
- Build disciplinary and cross-disciplinary inquiry groups where faculty can talk, learn from each other, analyze curriculum and student work, and examine content and/or teaching standards.

Professional Development and Faculty Support

- Encourage faculty buy-in for the program through personal interactions, dialogue, perks, and/or administrative support and directives.
- Find and/or train faculty and staff to advance the program goals.
- Provide professional development which is effective, appropriate and ongoing. Adopt and adapt effective professional development models which have proven successful in other STEM teacher preparation programs.
- Ensure that professional development activities designed to further the aims of the project are promoted not just to those working on the project, but to all at the institution who are interested. Enhance faculty knowledge, skills, and motivation will benefit participants, promote project success, and improve institutional effectiveness.
- Provide opportunities and training for project faculty and staff to become leaders within the program, division, institution, and in the larger educational community.
- Attract new faculty participants through activities, camaraderie, and the desire to be part of a successful endeavor.
- Mentor faculty to help them be better teachers and more effective in teacher preparation efforts.

INSTITUTIONS

Courses and Curriculum

- Create or modify courses for pre-service teachers so that they model effective teaching, include the specialized content knowledge needed to teach math and science, provide examples that future teachers can use in their own teaching, and use a variety of appropriate assessment strategies.

- Ensure that STEM courses highlight the connections within the discipline, across disciplines, and to the real world.
- Target specific lecture or lab sections for future teachers where content is integrated with pedagogy.
- Design courses for pre-service teachers specific to and taught at two-year colleges and articulated with baccalaureate institutions.

Collaboration

- Collaborate with four-year institutions to create clear, simple, and reasonable articulation pathways for future teachers.
- Create activities that help future teachers maintain connections to their two-year college, the teacher education program, and to other educators so that they have an ongoing support network.
- Collaborate with other two-year colleges to build programs, leverage resources, and influence state and national policy.

Evidence

- Define clear goals, set priorities, establish and implement a plan of action, and communicate the essence of the program to the college and the community.
- Develop a workable timeline to ensure reasonable progress toward program goals.
- Establish appropriate benchmarks for the program and describe the ways in which progress will be assessed.
- Collect and use college-wide data as another means to assess and improve the program.

Politics

- Garner the endorsement of college administration to give the program credibility and help make it a priority at the institution.
- Include a senior administrator as a leader on the project to ensure institutional buy-in and to signal to current and prospective funders, including government, private and corporate organizations, that the program has institutional backing.
- Leverage external mandates to advance the program and validate its work.

Visibility

- Build a high profile for the program at the two-year institution by regularly communicating with faculty, administrators, and staff about the program and its accomplishments; by highlighting it in campus media; and by showcasing the program at student activities and events.

- Sponsor events for faculty and/or students focusing on issues of teaching and learning.
- Publicize the participants' accomplishments and the program's K-16 partnerships through local news media.
- Raise program visibility through promotional items such as t-shirts, backpacks, pens, or notepads.

COMMUNITIES

Visibility

- Establish a professional development program for K-12 teachers at local schools.
- Institute joint professional development endeavors for in-service and pre-service teachers.
- Work with state and local boards to influence policy, practice, and funding relating to teacher preparation.
- Present program data and accomplishments at local and national professional meetings.
- Share program components with other institutions and the community using electronic and print media.
- Share program methods, accomplishments, and data with other colleges and organizations involved in STEM teacher preparation.
- Communicate the accomplishments of the program to elected officials, funding agencies, and the community.

♦♦ SYSTEMIC CHANGES ♦♦

A Description Of Curricular, Cultural, And Personnel Transformations Attributed To STEM Teacher Preparation Programs

An important result of highly successful STEM teacher preparation projects is the lasting impact on the institution. Curricular changes include the development of new courses or the revision of existing courses as well as the construction of entirely new majors or programs. Cultural changes manifest themselves as increased attention to, new funding for, and revised policies regarding teacher preparation efforts. Personnel transformations are demonstrated through new hiring guidelines, tenure and promotion policies, professional development activities focusing on teaching and learning, and a mindset among faculty and administrators that educating future teachers is everyone's responsibility.

For the projects represented at the Meeting Of The Minds Symposium, institutional changes were demonstrated through the following outcomes.

STUDENT FOCUSED OUTCOMES

- Students had the opportunity to begin their pre-service teacher preparation as freshmen rather than waiting until they transferred to a baccalaureate institution.
- Students in the program became ambassadors for the college.
- Program graduates were recruited and hired by local school districts for full-time teaching positions.
- Resource libraries for STEM teaching were developed and housed at two-year colleges and made available for pre-service and in-service teachers to use to improve classroom instruction.

FACULTY FOCUSED OUTCOMES

- Faculty discussion and collaboration about STEM teaching issues increased.
- A significant number of STEM faculty members became involved in the program.
- Partnerships among faculty in STEM disciplines and across disciplines were created.
- Program activities helped faculty improve their teaching methodologies and become aware of the importance of modeling good teaching practices for future teachers.
- Faculty teams that were developed as a result of the program work together in other educational efforts.
- Faculty retention and/or satisfaction increased through participation in the program.

INSTITUTION FOCUSED OUTCOMES

- Colleges provided financial and other types of support for the program during and after external funding period.
- Programs received funding from corporations or other external sources after their initial funding ended.
- Critical positions for program efforts, such as a director of teacher education, were institutionalized and supported by college funds.
- The program was given office space and the necessary funds to support the office.
- Academies for small groups of STEM majors or STEM pre-service teachers were created as part of the program and made a priority for institutional fund raising. Academies typically join teams to work collaboratively on practice-based activities to help them master specific content, concepts, or skills.
- Equipment acquired for the program continues to be used for STEM teacher preparation efforts and maintained by the institution.
- New courses, programs and activities persist beyond the tenure of external funding.
- Enrollment in STEM teacher education courses and programs increased.

COMMUNITY FOCUSED OUTCOMES

- State policies and practices were modified as a result of the program.
- Program components, activities, and/or strategies were adopted or adapted by other institutions.

♦♦ EVIDENCE-BASED RESULTS ♦♦

Improving The Assessment Of STEM Teacher Preparation Projects

One of the more challenging tasks for leaders of STEM teacher preparation projects is the assessment of the project's success. Typically, college faculty have limited training in project assessment and many two-year colleges have little or no institutional support available for this difficult task. Most projects will find it easier and more effective to hire someone with expertise and experience in evaluation, preferably evaluation of STEM projects or teacher preparation projects, to help them design and implement an evaluation plan. Even for those who do possess knowledge about assessment, finding metrics that accurately capture the content, skill, and attitudinal gains of the pre-service teachers is difficult. Beyond the primary impacts on pre-service teachers, it is also important to document other outcomes of these teacher preparation projects, such as changes in faculty teaching and attitudes as a result of involvement in the project, impacts on the K-12 classrooms where pre-service teachers spend time, and changes at the host institution.

Anyone planning a STEM teacher preparation project should determine what data is already available at the institution and what data will need to be collected. Almost any metric that will be used to document project success, such as course enrollments, completion and transfer rates, grades in pre-service teachers courses, and student attitudes, should be measured before work is done on the project. Without baseline data, collected prior to making changes in courses, teaching, or programs, it is much more difficult to document the impact of the project.

While the most desirable data would document the achievement of the students that these pre-service teachers will eventually teach, it is difficult to obtain this information. Most externally supported projects have a 2-5 year time span, which means they end about the time the project participants get their degrees and begin their teaching careers. Since it takes most new teachers 2-3 years to learn about their schools and their students and to "hit their stride" as teachers, it would be necessary to follow two-year college students for approximately a decade to reliably document the impact of their teacher preparation program. Given the limited years of funding for most STEM teacher preparation projects, obtaining this data is not a viable option. Instead, project leaders must focus on what they can measure today which best predicts effective teaching practices once participants become classroom teachers.

Because of their own education, most STEM faculty will look first to students' content knowledge as an indicator of preparation to teach. Content knowledge is vital for any teacher, but it is only one of many necessary facets of a teacher's portfolio. STEM educators should also consider other indicators of a college student's potential knowledge and skills as a classroom teacher. Assessing the many dimensions of a pre-service teacher's

knowledge and skills may not be a perfect predictor of later success as a K-12 teacher, but it will provide a tremendous amount of valuable information that can help guide a pre-service teacher's education.

There are a number of respected sources to use as starting points for building a robust assessment portfolio for a teacher preparation project. *Science for All Americans* (America Association for the Advancement of Science, 1989) addresses issues such as the nature of science, the nature of mathematics, the nature of technology, and effective teaching and learning. *Educating Teachers of Science, Mathematics and Technology: New Practices for the New Millennium* (National Research Council, 1998) provides suggestions for building and assessing teacher preparation programs. *How People Learn: Brain, Mind Experience, and School* (National Research Council, 1999) describes the physiology of learning and how to use that knowledge in a classroom setting. *Knowing What Students Know: The Science and Design of Educational Assessment* (National Research Council, 2001) focuses specifically on assessment.

While the exact nature of assessment must be matched to a project's particular context, aims, and local needs, most projects we surveyed shared a common set of metrics. These were: Knowledge, Communication, Skills, and Attitudes. Information about each metric is presented below.

KNOWLEDGE

Content Knowledge – a deep understanding of the subject within the context of the discipline, how it relates to other disciplines, and how it relates to the real world.

Pedagogical Knowledge – a deep understanding of learning theory, student psychology, how students' age and maturity level affects how they behave and learn, state and national standards, effective assessment strategies, and how each of these is used to enhance teaching and learning.

Pedagogical Content Knowledge – the specialized understanding that is specific to the teaching of a discipline, including relating facts and information to the foundations of the discipline, giving multiple representations of the content, anticipating questions, providing explanations, and analyzing student errors.

Self Knowledge – an understanding of self as learner and teacher.

COMMUNICATION

Outgoing Communication – using oral, written, visual, mathematical, scientific, and/or symbolic language to explain STEM content and explain points of view.

Incoming Communication – using listening and/or seeing skills to understand the viewpoint of others, to interpret unsaid messages, and to determine what students do and do not understand.

SKILLS

Management Skills – formulating a plan to achieve desired outcomes, using one's time and talents to effectively implement the plan, and efficiently adjusting to changing circumstances within a dynamic context.

Interpersonal Skills – ability to read the local context and work effectively within it, sensitivity to others' perspectives and needs, and a willingness to work toward the common good.

ATTITUDES

About Oneself – the expectation that one would be a lifelong learner, continue to be reflective about one's own learning and teaching, be a problem solver and critical thinker, and be confident as an educator.

About Others – the expectation that the students one teaches have the potential to succeed, a sense of responsibility to others as a teacher, and respect for others including educators, students, and parents.

About Teaching And One's Discipline For Faculty – the sense that teaching is grounded in trust and that a teacher must hold himself/herself to the highest standards as a mentor, a role model, and a leader. The belief that one's discipline's knowledge and skills are important not only for their inherent value and beauty but for their ability to enhance a student's educational success, and for their use in the real world.

About Teaching And One's Discipline For Pre-Service Teachers – the realization that STEM disciplines are crucial for students' success in the increasingly technological world, and that these areas are exciting and rewarding areas to teach. The understanding that a deep and rich content and pedagogical knowledge will result in better teaching and ultimately a deeper understanding for students; and the awareness that STEM disciplines must be taught in thoughtful, comprehensive, and interactive ways if students are to be engaged in these areas that can be challenging.

MEASUREMENT STRATEGIES

Effectively assessing teacher preparation projects requires both One Time Measurements and Change Over Time Measurements. A One Time Measurement gives a snapshot of the state of a system at the time of sampling. Examples include: sticking a thermometer in a beaker to measure the temperature, measuring what a pre-service teacher knows about a particular concept, and determining a teacher's level of confidence in teaching a specific science topic. A Change Over Time Measurement documents change and growth. Examples include: documenting the temperature change as a reaction proceeds, employing pre- and post-testing strategies, and ongoing sampling of data. The project team and/or evaluator must determine what to assess by One Time Measurements and what to assess by Change Over Time Measurements, based on the project's context and goals. Samples are presented below.

ONE TIME MEASUREMENTS

- Individual or group classroom presentations by pre-service teachers.
- Video of a pre-service teacher teaching a lesson in a classroom.
- Observation of a pre-service teacher during a field experience.
- Standardized tests and content exams for pre-service teachers.
- Group projects involving pre-service teachers.
- Development of an activity, lesson, or assessment instrument by a pre-service teacher.
- Review and critique of an existing activity, lesson, or assessment instrument by a pre-service teacher.
- Review of a pre-service teacher's portfolio.
- Interviews or panel discussions with pre-service teachers to determine their level of content and pedagogical understanding.
- Reflections by pre-service teachers about their content and pedagogical knowledge, level of understanding, and teaching experiences.

CHANGE OVER TIME MEASUREMENTS

- Changes in content and/or pedagogical knowledge as measured at multiple times by any of the strategies listed above.
- Changes in attitudes about STEM content and/or teaching.
- Reflections at multiple times by pre-service teachers about their content and pedagogical knowledge, level of understanding, and teaching experiences.
- Classroom observations of pre-service teachers teaching lessons at various times during their classroom experiences.
- Reflections at various times by pre-service teachers about improvements in their ability to design a lesson or activity, teach the lesson, revise and re-teach a lesson or activity, and about using feedback from faculty and peers to improve instruction.

♦♦ CHALLENGES ♦♦

Two-Year Colleges Continue To Face Obstacles In STEM Teacher Preparation

One of the most revealing and important outcomes of the Symposium was the identification of the challenges that even successful STEM teacher preparation projects face. A focused discussion of the many impediments to success led to the following list of pervasive challenges that the projects faced, and laid the foundation for the recommendations in this publication.

CHALLENGES RELATED TO STUDENTS

Recruitment

- Convincing college students to consider a career in teaching.
- Identifying STEM students who are interested in teaching on the secondary level.
- Convincing highly talented STEM majors to consider a career in teaching at the middle school or secondary level.
- Recruiting minority students to consider a career in teaching.
- Convincing graduating high school students and their parents of the value of beginning post-secondary education at a two-year college.

Retention

- Providing support for all students to persist in their chosen academic area and at the college.
- Helping students address personal and economic responsibilities outside of college which take their time and effort.
- Ensuring that minority students connect with the support mechanisms provided by the college.
- Keeping students in STEM majors.

Preparation

- Addressing the need for remediation in STEM areas for students interested in a career in teaching.
- Assisting prospective elementary school teachers in overcoming their fear of STEM content.

CHALLENGES RELATED TO FACULTY

- Providing professional development to ensure that faculty are well prepared and modeling good teaching practices for pre-service teachers.
- Ensuring vital coordination and communication between STEM and Education faculty.
- Convincing some STEM faculty members that K-12 teaching is an appropriate career for their high-achieving students.

CHALLENGES RELATED TO THE INSTITUTION

- Ensuring that teacher preparation is a respected activity for STEM faculty members.
- Eliminating inconsistent requirements between two- and four-year institutions.
- Developing smooth pathways, including articulation and transfer agreements, for pre-service teachers.
- Ensuring that robust articulation agreements are established at colleges which are not part of a statewide articulation mandates.
- Developing teams of STEM and Education faculty at two- and four-year institutions to work collaboratively on teacher preparation efforts.
- Obtaining necessary funding to allow adequate resources to be devoted to teacher preparation.
- Keeping up with changing state and federal requirements for testing and teacher preparation.

CHALLENGES IN THE COMMUNITY

- Convincing K-12 students to consider teaching as a profession.
- Improving the pay and working conditions for teachers.
- Elevating the status of teaching as a profession.

♦♦ RECOMMENDATIONS ♦♦

Collective Expertise And Experience Guides The Next Steps In STEM Teacher Preparation At Two-Year Colleges

The following recommendations reflect the collective knowledge of the participants at the Meeting Of The Minds Symposium. The group's combined experience and expertise are evident in the breadth and depth of the recommendations. The recommendations address issues participants consider vital to ensuring that STEM teacher preparation at two-year colleges continues to expand and succeed.

We believe that the recommendations will be useful to anyone involved in teacher education and that they will guide two-year college educators as they continue to make their unique and crucial contributions to STEM teacher preparation.

BUILD ROBUST PROGRAMS

- Establish programs that connect pre-service teachers with a community of individuals who share a common goal.
- Provide pre-service teachers with an identity and affiliation that remains with them after transferring to baccalaureate institutions and once they are classroom teachers.
- Establish a learning community for pre-service teachers which focuses on teaching and learning and promotes student success.
- Provide experiences for pre-service teachers that will help them realize that a teaching career is attractive, feasible, and attainable.
- Construct viable pathways for pre-service teachers to complete their degrees and credentials, and help them navigate the pathways to achieve their goals.
- Provide the support, guidance, and skills pre-service teachers need to succeed in college and in their careers.
- Establish ongoing faculty-student interactions.

RELY ON EVIDENCE

- Establish evidence-based outcomes which reflect the goals of the program.
- Collect reliable data and use it to validate the efficacy of the program.
- Train faculty to use data about teaching and learning to improve their own work.
- Use data about teaching and student success to improve the curriculum and the entire teacher preparation program.

RECRUIT AND RETAIN PRE-SERVICE TEACHERS AND LEVERAGE THEIR WORK

- Recruit local high school students into a teacher preparation program.
- Utilize pre-service teachers as peer tutors and mentors at secondary schools.
- Include middle and high school students in appropriate activities for prospective teachers in order to expand the STEM teacher preparation pipeline.
- Identify high achieving alums and develop their skills as spokespeople in order to share their work with the larger community and showcase the college's accomplishments in teacher education.

SUPPORT AND ENABLE FACULTY

- Offer professional development to college faculty which focuses on the discipline, on interdisciplinary areas, and on teaching and learning.
- Ensure that faculty members receive credit in the tenure and promotion process for their work in teacher preparation, teaching and learning, assessment, advising, and time spent in faculty-student interactions.
- Recognize faculty participating in successful STEM teacher preparation efforts with faculty awards, campus recognition, resources, and publicity.
- Create opportunities and infrastructure to support faculty who focus on teaching, learning, and student retention.
- Support faculty in their work with pre-service teachers and in the ongoing professional development of in-service teachers.
- Address issues of teaching in both higher education and at the K-12 level through faculty research groups, small group discussions, and professional development.
- Provide professional development opportunities which bring together K-12 teachers and higher education faculty.

SUPPORT AND ENABLE TEACHERS

- Provide teacher training that adequately prepares teachers to be effective in their own classrooms. This includes preparation in content, pedagogy, assessment, dealing with troubled students, interacting with parents, and navigating the intricacies of the school setting.
- Support teachers during their early years in the classroom through "on demand" professional development.
- Ensure that teachers have the classroom materials needed to effectively teach their subject, including math manipulatives, science equipment, and appropriate technology.
- Help teachers build support networks with colleagues from the K-12 and higher education sectors.

CREATE VISIBILITY

- Share the program accomplishments with the local community.
- Highlight the achievements of college students and alums to refute the perception that two-year colleges are second rate institutions.
- Inform city, county, and state legislators about the project's successes in STEM teacher preparation.
- Showcase alums who participated in STEM teacher preparation efforts.
- Publicize the accomplishments of the program and the alums through local print and electronic media.
- Inform policy makers about the role of two-year colleges in teacher education programs and invite them to visit the programs.

BUILD INSTITUTIONS THAT SUPPORT TEACHER PREPARATION

- Ensure that preparing the next generation of K-12 teachers is a fundamental part of the college's mission and an integral part of its strategic plan.
- Offer small class sizes, personal attention, support services, and reasonable tuition to ensure that pre-service teachers are able to complete their academic course of study and achieve their career goals.
- Develop strategies to maintain strong teacher education programs in the face of budget cuts or competing institutional priorities.
- Create accessible alternative certification programs to offer college students and career switchers the opportunity to enter the teaching profession.
- Create policies, practices, and structures that facilitate two-year colleges' ability to respond to state mandates and changes in the needs of students and society.

ENSURE THAT TEACHER PREPARATION AT TWO-YEAR COLLEGES IS WELL-SUPPORTED

- State Policy Makers:
  (1) Create high-quality alternative certification programs through two-year colleges to offer another path for college students and career switchers to enter the teaching profession.
  (2) Provide adequate resources to colleges for teacher preparation and to address students' remediation needs in STEM disciplines.
- All Policy Makers: Support teacher preparation efforts at two-year colleges through policy, legislation, and funding.
- Government Agencies: Address the need to expand STEM teacher preparation efforts at two-year colleges and support that work with dedicated programs and increased funding.

- Businesses and Industry: Stay informed about STEM teacher preparation efforts at local two-year colleges and support that work with financial contributions.
- Professional Organizations: Gather, analyze, and disseminate pertinent data related to teacher preparation at two-year colleges. Publicly support faculty engaged in teacher preparation. Publicize the successes of the organization's members in these endeavors.
- All Society: Recognize that two-year colleges provide a quality education for a vast number of students, many of whom would not have had the opportunity to pursue higher education otherwise. Show respect and appreciation for those who spend their careers educating the nation's young people.

♦♦ SYMPOSIUM PARTICIPANTS ♦♦

STEM Teacher Preparation Educators Whose Wisdom And Experience Guided This Publication

The participants ranged from a college president with decades of experience to young faculty members just building their careers. Most of the participants had been working in STEM teacher preparation for decades. The participants from professional organizations came from both disciplinary and shared purpose professional organizations, all of which were significantly involved in aspects of STEM education. But what every person at this symposium shared was a belief that STEM teacher preparation is critical to the educational success of students in the United States and a deep commitment to improving the preparation of the next generation of K-12 teachers.

Mary Kay Abbey
Department of Mathematics
Montgomery Community College
7600 Takoma Avenue
Takoma Park, Maryland 20912
240-567-1440
marykay.abbey@montgomerycollege.edu

Lynn Barnett
Vice President for Academic, Community, and Student Development
American Association of Community Colleges
One Dupont Circle
Washington, DC 20036
202-728-0200 x 204
lbarnett@aacc.nche.edu

Mary Beard
Department of Mathematics
Kapi'olani Community College
4303 Diamond Head Road
Honolulu, Hawaii 96816
808-734-9000
mbeard@hawaii.edu

Sadie Bragg
Vice President for Academic Affairs
Borough of Manhattan Community College
199 Chambers Street
New York, New York 10007
212-220-8000
sbragg@bmcc.cuny.edu

Virginia Carson
President
South Georgia College
Thrash Hall
100 West College Park Drive
Douglas, Georgia 31533
912-260-4399
virginia.carson@sgc.edu

Monica Clement
Director, Project Teach
Green River Community College
Mailstop: TEACH
14201 S.E 320th Street
Auburn, Washington 98092
253-833-9111 x 4359
mclement@greenriver.edu

Patricia Cunniff
Professor Emerita, Chemistry
Project Director, Phi Theta Kappa Project
Prince Georges Community College
310 Largo Road
Largo, Maryland 20774
301-927-7312
pcunniff@pgcc.edu

Dwain Desbien
American Association of Physics Teachers
Estrella Mountain Community College
3475 S 256th Avenue
Buckeye, Arizona 85326
623-536-8279
dwain.desbien@estrellamountain.edu

Dennis Ebersole
Math/Computer Information Sciences
Northampton Community College
3538 Green Pong Road
Bethlehem, Pennsylvania 18020
610-861-5300
ebersole@aol.com

June Gaston
Department of Mathematics
Borough of Manhattan Community College
199 Chambers Street
New York, New York 10007
212-220-8000
jgaston@bmcc.cuny.edu

Julie Guelich
Vice President of Academic Affairs
Normandale Community College
9700 France Avenue South
Bloomington, Minnesota 55431
952-487-8156
julie.guelich@normandale.edu

James Kelley
Dean, Natural and Behavioral Sciences
Pellissippi State Community College
10915 Hardin Valley Road
Knoxville, Tennessee 37933
615-694-6695
jkelley@pstcc.edu

Harriet Morrison
Associate Vice President of Academic Affairs
J. Sargent Reynolds Community College
Post Office Box 85622
Richmond, Virginia 23285
804-523-5811
hmorrison@jsr.vccs.edu

Brenda Reed
Department of Mathematics
Navarro Community College
3200 W. 7th Avenue
Corsicana, Texas 75111
903-875-7515
brenda.reed@navarrocollege.edu

Alice Session
Department of Biology
Austin Community College
5930 Middle Fiskville Road
Austin, Texas 78752
512-223-3321
asession@austincc.edu

Laurie Fathe
Higher Education Consultant
24388 Vincent Drive
North Olmsted, Ohio 44070
703-725-0869
lafathe@aol.com

Patty George
Department of Mathematics
Science, Engineering and Mathematics Division
Cerritos College
11110 Alondra Boulevard
Norwalk, California 90650
310-422-4591
pgeorge@cerritos.edu

Judy Kasabian
Department of Mathematics
El Camino Community College
16007 Crenshaw Boulevard
Torrance, California 90506
310-660-3593 x 3310
kasabian@elcamino.edu

Marilyn Mays
Executive Dean of Math, Science, & Sport Sciences
North Lake College
5001 North MacArthur Boulevard
Irving, Texas 75038
972-273-3000
memays@dcccd.edu

Meg Moss
Department of Mathematics
Pellissippi State Community College
10915 Hardin Valley Road
Knoxville, Tennessee 37933
865-694-6673
mvmoss@pstcc.edu

Terri Taylor
Education Division
American Chemical Society
1155 16th St. NW
Washington, DC 20036
202-872-4600 x 6168
t_taylor@acs.org

Linda Zarzana
Department of Chemistry
American River College
4700 College Oak Drive
Sacramento, California 95841
916-484-8011
zarzanl@arc.losrios.edu

♦♦ THE PROJECTS ♦♦

The Influence Of Two-Year Colleges On STEM Teacher Preparation

Projects represented at the Meeting Of The Minds Symposium were as varied as the colleges and organizations from which they originated. The colleges resided in urban, suburban, and rural areas with student populations that ranged from a few thousand to over thirty thousand. Some institutions reported very diverse student populations, some had a large enrollment of a single minority group, and some were overwhelmingly Caucasian. The projects shared one important characteristic – they were designed to best address the needs of their students and to function effectively within their specific context. Project leaders also recognized that their efforts were one piece of the collective work in STEM teacher preparation and that all members of the education community are essential to the successful preparation of the next generation of K-12 teachers.

PROJECT DESCRIPTIONS

EdTraC: Math-Science Educational Training Center

Normandale Community College – (NSF DUE 04-02166)
Julie Guelich – julie.guelich@normandale.edu

The goals of EdTraC are to increase the number of future teachers who choose a STEM specialty; improve the science, technology and mathematics preparation of all students in the K-8 licensure program; attract talented and diverse students into teaching; and strengthen ties with local high schools. In addition, the project enhanced the 2+2 partnership with Minnesota State University, Mankato, allowing student to complete the final two years of their degree at the Normandale campus.

EdTraC: Math-Science Education Training Academy

Normandale Community College – (NSF DUE 05-01851)
Julie Guelich – julie.guelich@normandale.edu

This component of the EdTraC project created a physics course and a mathematics technology course for pre-service teachers and established cohorts of pre-service teachers who were grouped by their curricular focus and career goals. Pre-service teachers at Normandale Community College had the opportunity to work as math and science tutors at partner high schools. This project strengthened the collaborations with partner school districts, Minnesota State University, Mankato, and professional organizations.

GET SMART

Austin Community College – (NSF DUE 03-02836)
Alice Session – asession@austincc.edu

GET SMART's approach to addressing the shortage of mathematics and science teachers included the establishment of education courses at the two-year college, strong student recruitment, and building seamless articulation agreements with local universities. In 2005, the Texas Higher Education Board established a new Associate of Arts in Teaching (AAT) degree that included education courses very similar to those of GET SMART, and mandated automatic transfer of AAT graduates to any publicly funded university in Texas. Currently, Austin Community College annually offers 25 sections of Introduction to the Teaching Profession and 12 sections of Introduction to Special Populations, courses developed during the GET SMART project.

Pathways to Teaching

J. Sargent Reynolds Community College – (NSF DUE 04-02552)
Harriet Morrison – hmorrison@jsr.vccs.edu

This project focused on curriculum development, early field experience for pre-service teachers, and pathways for high school students to transition to the community college. Seven courses for pre-service teachers were developed, including one dual enrollment course for both high school and two-year college students. Pre-service teachers participated in math and science tutoring and Middle School Summer Camps, which enhanced their pre-professional experience. The project included on-site advising at the high schools, campus visits, and mentoring for high school students to ease their transition to the community college. The project also provided scholarships for high school and college students interesting in pursuing a career in teaching.

Preparing Tomorrow's Science & Mathematics Teachers: The Community College Response

Phi Theta Kappa – (NSF DUE 03-02815)
Patricia Cunniff – pcunniff@pgcc.edu

This project paired faculty and administrators from two-year colleges with mentors from partnered two- and four-year institutions with successful STEM teacher preparation programs. The mentors helped the two-year colleges design and implement STEM teacher education approaches appropriate to their institution's context. Project activities included: two National Teacher Preparation Conferences; mentor services; site visits; a networking newsletter; a case study monograph; the Best Practices Conference to recognize and share exemplary work in STEM teacher preparation programs at the participating two-year colleges; and the Best Practices Conference proceedings. The project was funded for a second round by the National Science Foundation, providing a total of 35 two-year colleges the opportunity to participate in this project.

Science and Math Teachers for the New Millennium

City College of New York Community Colleges
June Gaston – jgaston@bmcc.cuny.edu

This project involved collaboration between Borough of Manhattan Community College and four other campuses within the CUNY system to improve the curriculum for pre-service teachers and articulation among the institutions. Pre-service secondary STEM teachers participated in a program which provided education courses, seminars, and internships. The seminars and courses were offered at each of the partner campuses via videoconferencing and web-based learning resources. The faculty training component promoted strategies for student leadership training and better advisement, particularly during the transfer process.

Science FEST (Future Elementary School Teachers) Project

El Camino College – (NSF DUE 02-01981)
Judy Kasabian – kasabian@elcamino.edu

Science FEST was initially funded by the National Science Foundation and later supported by Northrop Grumman Space Technology. Seventy future teachers participated during the six years of the project, making over a thousand teaching presentations in two dozen schools in the Los Angeles area. Students worked with a science content specialist and a teaching specialist to develop modules in space and physical sciences appropriate for K-9 students. The students taught the modules several times, first for their peers, and then in the K-9 classroom, each time receiving feedback. The modules developed by the participants are available at the project website [www.science-fest.org]. Project participants also made presentations at professional meetings, such as the National Science Teachers Association and the California Science Teachers Association.

Teacher TRAC

Cerritos College – (NSF DUE 05-01326)
Patty George – pgeorge@cerritos.edu

The Cerritos College Teaching Secondary School Scholar Partnership Program (TS^3P/TS_3P) is a partnership with California State University, Long Beach and John Glenn High School. The focus of the program is to recruit, prepare, and seamlessly transfer students pursuing both a major and a secondary school credential in mathematics or science. Mentoring, counseling, advising, education coursework, early fieldwork, and professional development for faculty teaching the pre-service teachers are cornerstones of the program. Teacher TRAC received the Phi Theta Kappa Teacher Preparation Program Award, recognizing exemplary efforts in preparing students for careers in education. Teacher TRAC also received state funding to develop and implement a technical education program for pre-service teachers.

Tennessee Board of Regents Teacher Preparation Project

Pellissippi State Community College – (NSF DUE 05-01440)
Meg Moss – mvmoss@pstcc.edu

This project involved two- and four-year institutions in Eastern Tennessee – Pellissippi State, Roane State, Chattanooga State, Motlow State, Walters State, Northeast State Community Colleges, Tennessee Technological and East Tennessee State Universities – which worked collaboratively to develop and institute K-6 pre-service teacher education courses in math, science, and teaching with technology as well as professional development activities in those areas, modeling the work of the MASTER project.

The Math and Science Teacher Education Resource (MASTER) Program

Pellissippi State Community College – (NSF DUE 03-02907)
Jim Kelley – jkelley@pstcc.edu

The MASTER program supplied professional development and student support and funded the creation of five new courses, three in science and two in math, for future teachers. During this grant's duration, the State of Tennessee Board of Regents allowed Pellissippi State Community College, in cooperation with its four-year partner institution, Tennessee Technological University, to offer the junior and senior years of the K-6 teacher education program at the Pellissippi State Community College campus.

The Mathematics and Science Partnership of Greater Philadelphia (MSPGP)

Northampton Community College – (NSF DUE 03-14806)
Dennis Ebersole – ebersole@aol.com

The Mathematics and Science Partnership of Greater Philadelphia brought together 46 school districts and 13 higher education institutions to address the improvement of secondary mathematics and science instruction. New courses and programs of study for pre-service teachers were created, articulation agreements were finalized, and pre-service teachers worked in a professional development school with a highly diverse population. The MSPGP model included a "Core Connector" organizational structure that helped facilitate partnerships between high school teachers and higher education faculty.

The Professional Development Programs of ACS

American Chemical Society
Terri Taylor – t_taylor@acs.org

The American Chemical Society (ACS) provides professional development for K-12 in-service teachers using workshops (1-5 days) and webinars (1-3 hours). Topics include Green Chemistry, Chemistry in the Community, Inquiry-based Advanced High School Chemistry, and Inquiry in Action for K-8 teachers. ACS publishes a variety of resources for educators and is currently exploring ways that it can improve the preparation of pre-service teachers. A selection of the resources may be found at their website [www.acs.org].

INDICATORS OF SUCCESS

The efficacy of each project was determined by a variety of means. In addition to quantitative data, many other types of evidence can demonstrate project success. These indicators of success can effectively capture the nuances and personality unique to each project. We have organized the indicators for success into four categories – curriculum, college students, faculty, and the institution.

Curriculum

- New courses and programs were created for pre-service teachers.
- New courses became part of the college's permanent curriculum.
- New courses were articulated with baccalaureate institutions.

College Students

- Enrollments in programs and courses designed for pre-service teachers increased.
- Students in targeted programs completed more STEM course credits than other pre-service teachers.
- Students who plan to be elementary and secondary teachers expressed increased interest in STEM disciplines.
- Students scored well on STEM content exams.
- Students scored well on national standardized tests.
- Students' confidence in their STEM content knowledge increased.
- Students' confidence and ability to teach STEM content in the K-12 classrooms increased.
- Students' teaching ability and strategies were confirmed through observation using a standard protocol.
- Students developed STEM instructional materials that were used by other educators.
- Students became mentors in local K-12 schools and ambassadors in the community.
- Students were selected for STEM internships at four-year institutions and federal or corporate laboratories.
- Students were awarded scholarships at their transfer institutions.
- Students were recruited to serve as interns and instructional aides at local K-12 schools.
- Students were recruited for employment by local K-12 school districts once they completed their academic programs.
- Students, once they completed their academic programs and were hired as K-12 teachers, achieved leadership positions at school sites.

Faculty

- Faculty members incorporated STEM teaching pedagogy appropriate for pre-service teachers into their college courses.
- Faculty who were involved in STEM teacher preparation projects modified the pedagogy in all of their courses.
- The number of faculty members interested in teaching pre-service teachers increased.
- Faculty members sought out professional development to help improve their own teaching.

The Institution

- Programs in STEM teacher preparation were funded by the institution or from another source after their initial funding expired.
- Programs forged robust articulation agreements with four-year institutions.
- Programs were given regular budget lines at their institutions.
- Programs received permanent space at the institution for STEM teacher preparation efforts.
- Programs contributed to the research in teaching and learning.
- Programs were showcased at the institution, in the local community, statewide, and nationally through publications, presentations, and awards.

♦♦ ACKNOWLEDGEMENTS ♦♦

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THE NATIONAL ASSOCIATION OF COMMUNITY COLLEGE TEACHER PREPARATION PROGRAMS

The National Association of Community College Teacher Preparation Programs (NACCTEP) is one the nation's leaders in improving teacher preparation. It has generously welcomed this publication as one of the resources it provides for faculty and administrators, and has made it available on their website [www.nacctep.org]. We thank its past president, Virginia Carson, for her valuable insights at The Meeting Of The Minds Symposium, and the staff at NACCTEP for their ongoing support.

MEETING OF THE MINDS SYMPOSIUM PARTICIPANTS

This publication is the work of the participants who attended the Meeting Of The Minds Symposium and represents many decades of collective knowledge and experience. We gratefully acknowledge their openness in sharing their failures along with their successes, their hard work, and their valuable input before, during, and since the Symposium. But more importantly, we thank them for their insight and leadership in STEM teacher preparation at their own institutions and beyond.

EDUCATORS WORKING ON STEM TEACHER EDUCATION EFFORTS

It is with the greatest appreciation and respect that we acknowledge the two-year college faculty and administrators who have dedicated themselves to helping prospective teachers gain the knowledge, skills, and confidence to become effective K-12 educators.

The new generation will have the opportunity to solve many global issues: health care, energy security, and the global food crisis to name just a few. Given this, the missing ingredient is a better knowledge of math and science and its power to provide solutions to these problems. Technology can and will change the world. For this younger generation to be the force for good they want to be, they need to understand that the new literacy of the 21st century includes math and science.

••Tom Luce
CEO, National Math and Science Initiative

♦♦ RESOURCES ♦♦

The Meeting Of The Minds participants utilized a variety of resources which were valuable in their STEM Teacher Preparation efforts. The following is a list of resources considered helpful.

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Web Resources

Case Studies in Science Education
http://www.learner.org/resources/series21.html

How People Learn: Brain, Mind, Experience and School: Expanded Edition
http://www.nap.edu/openbook.php?record_id=9853&page=1

Private Universe Project
http://www.learner.org/resources/series29.html

The Brain: Teaching Modules
http://www.learner.org/resources/series142.html

The Mind: Teaching Modules
http://www.learner.org/resources/series150.html

The Science of Teaching Science
http://www.learner.org/resources/series90.html

Improving science education for all children in our public schools is also critical to developing a broader appreciation for science and the scientific method in society. I believe that teachers are the most critical element in improving education. Nothing makes more of an impact on our children than a well-trained, caring, and dedicated teacher.

••Congressman Rush Holt, Ph.D., Physicist
American Physics Society News
October 1999

♦♦ REFERENCES ♦♦

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♦♦ APPENDIX ♦♦

PRE-SYMPOSIUM QUESTIONNAIRE FOR A MEETING OF THE MINDS PARTICIPANTS

A MEETING OF THE MINDS is a project recently funded by the National Science Foundation. The purpose of the project is to attain the following six objectives:

- Convene leaders in teacher preparation in the STEM disciples with various years of experience at the task from a wide cross-section of two-year schools.
- Provide a forum to discuss best practices and challenges in STEM teacher preparation in 2008, allowing the participating institutions to further enhance their knowledge.
- Assist participants organize and present their work such that faculty at community colleges across the country can adopt and adapt the teacher preparation practices at their own institutions.
- Examine ways in which to expand the group of colleagues to include a wider audience.
- Produce a document presenting the best practices in STEM Teacher Education from symposium participants.
- Make recommendations to the National Science Foundation about ways to enhance the ATE Teacher Education track.

We ask you to provide us with information about your work in the teacher education efforts at your institution prior to the symposium in order for us to compile the information, share the responses with the symposium attendees, and guide us as we design the specific components of the agenda for the day.

Please provide your responses directly on the questionnaire. Thanks!

Participant Information

1. Your Name
2. Your Position at the Institution or Organization
3. How are you involved with pre-service teacher preparation? [Describe any classes you teach or programs in which you are involved.]
4. How long have you been involved with pre-service teacher preparation at your institution or organization?

Institution Information

5. Name of the Institution
6. If you are part of a community college, provide the following information about your institution. If you are from another type of organization, please give a brief description.
   - Location (city and state)
   - Enrollment (number of students attending your institution, and in STEM teacher preparation courses/tracks/programs, including elementary)
   - Student Demographics (both institutional and in STEM teacher preparation, including elementary)

7. What is the structure of STEM pre-service classes, programs, or tracks at your institution? Do you have a focus on any particular grade level or discipline?

8. If there are any particular challenges at your institution or in your state with regard to teacher preparation, please describe them. These could include recruitment, retention, articulation, or other issues.

9. What changes have occurred in pre-service teacher preparation at your institution in the last ten years, or however long you've been involved, if less than ten years? In what capacity have NSF-funded projects contributed to the changes at your institution? Please list and describe the changes. Please include the grant number for the NSF-projects involved.

10. What challenges do you face specifically in teacher preparation in the STEM disciplines?

NSF – Funded Project Information

11. For each NSF-funded project in teacher preparation, please include the following information.

PROJECT #1

- NSF grant number
- Category (e.g. ATE Teacher Preparation)
- Years of NSF funding (e.g. 2002-2005)
- How you were involved in the NSF funded project?
- Project abstract (please include here or as an attachment)
- Ways in which the project or aspects of the project has been institutionalized.

Best Practices

12. Which aspects of your pre-service teacher preparation efforts are working the best?

13. In what ways, if any, have NSF-funded projects, both your own and others', contributed to these best practices? Please describe the best practices. Please include the grant number, if known.

14. What one thing do you want to be sure we, NSF, and others know about what is happening in teacher preparation in the STEM areas at your institution?

15. What specific strategies have been effective in institutionalizing NSF-funded projects (or aspects of a project) at your institution, and what challenges did you encounter?

Assessment Of Teacher Preparation Efforts And Pre-Service Teacher Content Knowledge

16. How do you assess success in your pre-service teacher preparation efforts? Please provide or attach any assessment instruments that have been developed.

17. What strategies or assessment instruments have you used to determine pre-service teachers' STEM content knowledge level? Please include here or as an attachment.

18. Please share with us the data your institution has collected to evaluate the success of a teacher preparation program, course, or other effort. Please include here or as an attachment.

Publications And References

19. Have you published or presented at a conference, meeting or public forum any of your work in teacher preparation? If so, please include the references.

20. Have there been any articles, research, and/other materials which have been particularly meaningful and/or helpful as part of your work in teacher preparation? Please list the references. We plan to prepare a Reference List as a resource to all participants.

At The Symposium

21. In what ways do you anticipate that our discussions at the symposium will help you and your institution continue on your STEM teacher preparation efforts?

22. Is there anything else you want us to know before the symposium convenes?

We appreciate your time and expertise in completing this questionnaire. We anticipate that when we compile all of the responses from the participants we will have a clearer and broader view of the STEM teacher preparation efforts funded by NSF. We look forward to a valuable exchange of ideas, practices, and synergistic brainstorming at the symposium.

Respectfully,

Laurie Fathe and Judy Kasabian

Education is the most powerful weapon which you can use to change the world.

••Nelson Mandela