

a. Results from prior NSF support. PI Wolff is a Senior Personnel on the \$3,313,383 Newark Public Schools Systemic Initiative in Mathematics grant (NSF 0138806) for 7/1/02-6/30/07. May Samuels is the PI. The focus is professional development for grades 1-8 teachers. It does not involve partnering STEM students with teachers. Co-PI West is Co-PI with Stefanie Brachfeld on the \$197,649 Acquisition of a Vibrating Sample Magnetometer at Montclair State University grant (NSF 0521069), Major Research Instrumentation, Earth Sciences Division for 8/15/05-8/14/06. The project does not involve K-12 schools.

b. Goals and Objectives. This project matches four science and four math graduate students at Montclair State University (MSU) each year with eight middle grades science and math teachers. Over the five-year grant period, a total of 16 pairs of science-math Fellows are placed in five contiguous urban/suburban districts in northern New Jersey (NJ). Project activities include recruitment and training of Fellows and teachers; development, delivery, integration and district adoption of interdisciplinary science and math units; and evaluation of the project's impact on all participants. Fellows are trained in inquiry-based interdisciplinary teaching practices consistent with state and national standards. As a team, science and math Fellows, their cooperating teachers, and MSU Research Advisors (RA's) design interdisciplinary units based on scientific processes and field experiences, and prepare students for an annual Science/Math Day. Evaluation activities guide the project and assess its efficacy.

The middle grades were chosen for several reasons. First, those school years are critical for engaging students in science and math. The waning of students' interest in science and math during those years is especially pronounced in girls (Strauss & Subotnik, 1994), Hispanic students (Sorge, Newsom & Hagerty, 2000), and students with disabilities (Anderman, 1998). Second, not all middle grades science and math teachers have adequate training in the disciplines they teach (Ingersoll, 2001; Loucks-Horsley, 1999; NRC, 2000) and few have training on interdisciplinary instruction (Berlin, 1994). Finally, MSU has well-established and strong programs in middle grades science and math that provide the infrastructure for the proposed project. This project implements recommendations of *Rising Above the Gathering Storm* (NAP, 2006) for improving science and math education by strengthening the skills of teachers and providing students with proven inquiry-based learning, laboratory, and research experiences.

GOAL 1: Equip Fellows with skills necessary to excel in STEM careers.

Objective: Improve Fellows' team and communication skills, and career opportunities.

- Fellows communicate the importance of scientific processes to middle grades students.
- Fellows present research results in an accessible way to students at Science/Math Day.
- Fellows work in teams to develop and teach interdisciplinary lessons and units.
- Fellows present units to other Fellows, RA's, project personnel, and district representatives.
- Fellows broaden career opportunities through interactions with grant-related personnel.

Objective: Develop Fellows' understanding of middle grades science and math education.

- The Summer Institute for Fellows focuses on inquiry-based approaches using materials from NSF-supported Connected Mathematics Project (CMP) and Full Option Science Systems (FOSS), and Science and Technology for Children (STC).
- Monthly Professional Development Workshops connect the National Council of Teachers of Mathematics (NCTM) Standards, National Science Education Standards (NSES) and NJ Core Curriculum Content Standards (NJCCCS) to the classroom.
- Experienced teachers, with the RA's and project staff, provide "on-the-job" training.

GOAL 2: Enable teachers to inspire students in science and math.

Objective: Strengthen teachers' knowledge of science and math content and research.

- Monthly workshops focus on science and math content and the scientific process.

- Fellows share their content and research expertise with teachers.
- RA's visit schools monthly and provide guidance on content and ways to connect middle school curricula with cutting-edge science and math research.

Objective: *Familiarize teachers with innovative approaches to teaching science and math.*

- Teachers attend Summer FOSS/STC/CMP workshops.
- Monthly workshops emphasize technology, interdisciplinary pedagogy, inquiry-based lessons, cooperative learning, and inclusion instruction for students with Limited English Proficiency (LEP) or Specific Learning Disabilities (SLD).
- Fellows share information about innovative teaching methodologies from the Summer Institute, work with RA's, and graduate coursework.
- International experiences connect to middle grades curricula and teaching practices.

GOAL 3: Increase middle grades students' interest and achievement in science and math.

Objective: *Strengthen interdisciplinary connections in science and math classrooms.*

- Students, Fellows, and teachers engage in field experiences at appropriate sites, based on an annual interdisciplinary theme. These themes also motivate interdisciplinary units.
- The units, inspired by inquiry-based pedagogies and connected to cutting-edge research, become an integral component of the districts' permanent curricula.
- Classes prepare for, compete in, and judge projects at an annual Science/Math Day.
- Science-math Fellows, teachers, and RA's meet regularly to plan and refine lessons.

Objective: *Improve science and math achievement of underrepresented minority groups, in particular Hispanic and recent immigrants, as well as students with LEP or SLD.*

- Fellows and RA's are recruited to reflect the diversity in the schools.
- LEP and SLD experts lead Summer Institute sessions and monthly workshops.
- LEP and SLD experts review curriculum units for their use in inclusion classes.

Objective: *Expose students to cutting-edge research, scientific methods, and the benefits of pursuing science and math in post-secondary education and as a career option.*

- Fellows and teachers implement experiments and projects that promote the scientific process. They use current technology and dynamic software, making connections to cutting-edge research in ways that are appropriate for middle grades students.
- Fellows are role models for the middle grades students.
- College of Science and Mathematics (CSAM) faculty, Fellows, industry and minority group representatives, and international scholars present their research and industry-related issues during Science/Math Day. They discuss examples of cutting-edge research that are extensions of middle grades science and math.
- CSAM students conduct campus tours for middle grades students during Science/Math Day.
- Students converse about research methodologies through interactive videoconferences with scientists in the rainforests of Panama and other habitats.
- Selected Fellows and teachers collaborate with international researchers and educators. These collaborations put middle grades math and science instruction in a global context.
- Students correspond and exchange ideas with students in other countries. They conduct comparative studies such as those modeled after the Noon Day Project.

GOAL 4: Institutionalize project activities at MSU.

Objective: *Enhance STEM graduate programs by promoting communication and teamwork.*

- Nominated and selected CSAM students present research results at Science/Math Day.
- Graduate students gain exposure to field experiences and interdisciplinary work.

Objective: *Strengthen University's partnerships with local school districts and industry.*

- Use project evaluation results to guide the institutionalization of the project.

- Work with MSU’s Development Office and the CSAM Advisory Board to obtain support from local industry to continue the project.

Objective: *Develop post-baccalaureate science programs for middle grades teachers.*

- Deepen MSU faculty’s awareness of education issues and commitment to K-12 education.
- Develop and institutionalize an interdisciplinary course modeled after this project.

c. Project Plan

MSU’s expertise and success with in-service science and math teacher training

CSAM faculty members maintain close connections with the public schools. During 1993–1997, members of the math faculty worked with 85 middle grades teachers from Newark, NJ’s largest district. Selected teachers continued with a sequence of five content courses based on the NCTM content standards. Concurrently, MSU was the primary provider of professional development on the use of hand-held technology to enhance the teaching of science and math in NJ.

MSU’s Professional Resources in Science and Mathematics (PRISM), a regional NJ Statewide Systemic Initiative center affiliated with the National Science Resources Center, is housed in the Bristol-Myers Squibb Center for Science Teaching and Learning. It sponsors professional development activities that enrich school science and math instruction using research-based pedagogies. Through PRISM’s Adopt-A-Prof program, middle grades science and math classes “adopt” a professor for the school year. Faculty members visit their school monthly and work with teachers to deliver lessons. The PRISM Rainforest Connection videoconference engages students with scientists in Panama and other locations. CSAM hosts a variety of campus events for teachers and students. Every year several hundred middle and high school students compete in the Northern NJ Science Olympiad and attend Math Day where faculty members make student-friendly presentations on thought-provoking topics.

In 2001 MSU was awarded a three-year \$2.5 million High-Tech Workforce Grant to improve the content and pedagogical knowledge of NJ’s elementary and middle grades teachers. Two results of that grant were a post-baccalaureate certificate and a new MA degree, both in the Teaching of Middle Grades Mathematics. During the Spring 2006 semester more than 80 practicing teachers were actively enrolled in those programs. Teachers from each of the five districts have participated in math education programs and PRISM workshops at MSU.

The three PI’s have a variety of experiences in the schools. For example, PI Wolff recently taught three in-service math courses in a participating district and PI Munakata is an Adopt-A-Prof in a school in another participating district. PI West has developed materials that address the NJ Astronomy Standards, regularly delivers science professional development workshops, and conducts monthly Astronomy Nights that attract local middle grades students and parents.

Description of Local School Districts

The participating school districts—Kearny, North Arlington, Lyndhurst, Rutherford and East Rutherford—are located in NJ’s industrial corridor that runs northward from Newark. This area is becoming increasingly urban and experiencing an influx of immigrants from Latin America, Eastern Europe and Asia. Immigrant children create a diverse and changing student population resulting in new demands and challenges. Kearny, the largest of the five districts, is an urban-enterprise zone. English is a second language for 70% of the students in the district. At the middle grades, 45% of the students are Hispanic. Franklin, a Title 1 school, is expected to participate. In the last year for which data are available, Kearny students with LEP and SLD had math proficiency rates lower than that mandated by the state. Economically disadvantaged students in the district had a math proficiency rate markedly lower than others in the district.

Similarly, North Arlington has a large number of students with SLD (20%) and LEP. Math scores for all students lag far behind language arts literary scores on NJ’s Grade Eight

Proficiency Assessment. The North Arlington Middle School is a Title 1 school. In Lyndhurst, the collaborating schools are expected to be Roosevelt and Washington, both of which receive Title 1 funding. The district is continually seeking to improve the achievement of all students in science and math and to strengthen the content knowledge of its science and math teachers. In Rutherford, both the Pierrepont and Union schools will participate. One of that district's goals is to increase math achievement for all NCLB subgroups including special education and Hispanic students. In East Rutherford, 65% of the middle grades students belong to a minority group, with 36% identified as Hispanic. Twenty-seven percent of the middle grades students have disabilities that affect their schooling. The Faust School, East Rutherford's middle school, is a Title 1 school.

The challenges of narrowing the achievement gap among the NCLB subgroups and enhancing the knowledge of the middle grades science and math teachers demonstrate the need for the Fellows in the Middle project in these districts. In all five districts, only a few middle grades science and math teachers hold degrees in their subject area. Participating in the Professional Development Workshops and working with Fellows and RA's will strengthen the content knowledge of the teachers. Significant state and federal funds go to large urban northern NJ districts such as Newark and Paterson. As a result, smaller districts in the same geographical region have often been overlooked. This project is a timely opportunity to enhance STEM instruction in the five participating districts.

Annual Interdisciplinary Theme

Each year, an interdisciplinary theme based on state and national science and math standards is identified. These annual themes guide training activities, the selection of field experiences and the development of curriculum units. The annual themes are expected to be Earth History, Planetary Science, Populations and Ecosystems, and Chemical Interactions. These broadly defined themes provide latitude for all Fellows and teachers to develop lessons with interdisciplinary connections.

Training Activities

In early June, the PI's conduct a three-hour introductory seminar for teachers, Fellows, and RA's. The seminar outlines the project's goals, objectives, activities, and expectations.

Summer Institute: All Fellows participate in an intensive two-month Summer Institute at MSU led by PI's Munakata and West. By the end of the Summer Institute, Fellows have 1) visited schools; 2) learned about state and national science and math standards; 3) been trained on the use of science and math inquiry-based materials; 4) participated in LEP and SLD workshops; 5) received training at field sites; 6) been trained on making scientific methodology and cutting-edge research relevant to middle grades students; 7) developed curriculum units for hands-on science and math; and 8) presented units. Fellows have the option to count their summer work toward a 3-credit graduate-level elective course. After Year 1, returning Fellows participate in the Summer Institute as resources for new Fellows and assist with refining curriculum units.

During the first two weeks of the Institute, Fellows are introduced to middle grades science and math education, and become familiar with the NCTM Standards, NSES, and NJCCCS. Materials such as the NSF-supported *Developing Mathematical Ideas* and the *Annenberg Case Studies Series* tapes expose Fellows to authentic episodes of middle grades students' mathematical and scientific explorations. In contrast, by using the case studies in *Windows on Teaching Math* (Merseth, 2003), Fellows explore teachers' experiences. In addition to science and math content-driven discussions and explorations, issues of diversity, learning styles, and equity are explored. Anna Mazzaro (LEP expert) and Dr. Fran Greb (SLD expert) each lead full-day workshops that address cultural considerations and methodologies for teaching science and math in inclusive classes. The Summer Institute is scheduled to coincide with the end of the

school year so that Fellows and RA's can observe their cooperating teacher and students for at least one full day. Fellows and RA's also meet with principals and gain a sense of a typical school day. This visit spurs context-driven discussions about teaching and learning in middle grades classrooms.

During the next two weeks, Fellows attend FOSS/STC and CMP workshops. Part of the teachers' stipend is allocated to serve as an incentive for them to attend these workshops. Each workshop involves three full days and a one-day follow-up session. To promote interdisciplinary connections, all Fellows attend both workshops. Each year, a different FOSS/STC unit is used, consistent with the annual theme. The CMP workshop addresses that theme while focusing on meaningful uses of manipulatives, modeling, and cooperative learning. Although not all school districts will adopt these materials immediately, the Fellows' and teachers' exposure to these innovative teaching materials is expected to influence their instructional methodologies and philosophies. The workshops provide approaches to integrating scientific methods and current STEM research topics into middle grades instruction. RA's are invited to attend the workshops.

For the remainder of the Institute, science-math Fellow pairs receive training at two field sites and work with RA's and project personnel to develop two curriculum units. Both the field sites and units are related to the annual theme. Training at the field sites includes suggestions for making cutting-edge research experiences relevant to middle grades students. The units are developed during the Institute, but refined and revised during the school year. In August, Fellows present their materials to PI's, RA's, and other Fellows. A rubric, used in MSU methods courses and approved by the National Council for Accreditation of Teacher Education, is used to evaluate the units. After implementation and revision, units are posted on the project website as resources for other Fellows and teachers.

Professional Development Workshops: During the academic year, Fellows and teachers attend monthly two-hour evening workshops led by PI Munakata. The workshops center on effective inquiry-based approaches to science and math. Activities include explorations with technologies such as graphing calculators, calculator based laboratories, Geometer's Sketchpad, Fathom, Excel, and Voyager. Other sessions explore alternative teaching methods such as the use of structured group work, connections to age-appropriate literature, scientific processes, and interdisciplinary science and math instruction. Participants are introduced to other Standards-based, NSF-supported curricula such as Mathematics in Context and EarthComm. Exposure to these materials influences Fellows and teachers as they develop lessons. While Fellows and teachers at the same school are in constant contact, the workshop provides a forum where participants from different districts share ideas, concerns, and questions. A Listserv promotes communications outside of meeting times.

Team Meetings: Math-science school teams of Fellows and teachers meet at regularly scheduled times each week to reflect upon the past week and engage in short- and long-term planning. The RA's participate once a month to serve as resources on content and research methods.

Portfolios: Fellows create portfolios that include lesson plans, weekly reflections, and sample student work. Portfolios are evaluated to determine whether they address state and national standards and are consistent with the project's goal of enacting interdisciplinary, inquiry-based teaching. Project staff use material selected from portfolios for evaluation and promotional purposes. Selected lesson plans are posted on the project website and serve as resources for other teachers during and beyond the funding period.

Description of Middle Grades Activities

Fellows in the Classroom: Fellows are in classrooms for two full days each week, gaining full exposure to day-to-day activities. They are still able to attend courses, colloquia and seminars and conduct research at MSU. The usual middle grades teaching load is five classes. In all but one district, teachers are assigned one grade level. In Lyndhurst, a few math teachers are assigned multiple sections of grades 7 and 8. Fellows matched with those teachers would support instruction for both grades. Fellows observe classes for the first three weeks of the school year, becoming familiar with the school infrastructure, students, teaching style of their cooperating teacher, curriculum, and administration. Fellows and PI's convene weekly in September so that Fellows have ample opportunity to clarify their understanding of classroom mechanisms before participating more actively.

Starting in October, Fellows and teachers team-teach lessons. The Fellow's role is to infuse the curriculum with science and math content. Fellows also introduce innovations such as new technologies or laboratory techniques, promote scientific processes, and share the results of recent research. Fellows seek and make connections between their research and content expertise and the middle grades curriculum. Weekly meetings, Professional Development Workshops, and monthly meetings with RA's provide opportunities to discuss such connections.

Curriculum Units: In each of four years, two interdisciplinary curriculum units are developed, addressing specific NJCCCS science and math standards. The annual theme guides the development of the units implemented in the weeks surrounding the fall and spring field experiences. Sites such as the NJ School of Conservation, Sterling Hill Mining Museum, Dreyfuss Planetarium, Essex County Environmental Center, NJ Marine Sciences Consortium, Great Swamp National Wildlife Refuge, Liberty Science Center, and the Intrepid Sea-Air-Space Museum have been identified. Each site has resources to train Fellows and the project team. The units are aligned with *Project 2061* to emphasize and connect big ideas and address age-appropriate concepts and process skills in an inquiry-guided way. As an example, an interdisciplinary unit for the Sterling Hill Mining Museum would include math explorations on crystals as polyhedra, and science investigations on liquid crystals and the formation of minerals in the earth's crust.

At the end of each semester, Fellows present their curriculum units from that semester to project personnel and representatives from all five school districts. From the presentations, district representatives understand how part or all of the units can be integrated into their middle grades science and math curricula. Although the interdisciplinary units are designed for use with specific sites, they can be adapted to other locations. A unit for the Great Swamp National Refuge might involve students estimating the number of different plant species in the refuge by analyzing the species found in a small area. Students would use middle grades science and math skills that connect to cutting-edge research—for example, to the work being conducted in a Panamanian rainforest as recently reported in the New York Times (Jackson, 2006). This student investigation could be conducted in other parks. This flexibility increases the functionality of the units and provides an assurance that grant activities are sustained beyond the funding period.

Science/Math Day: Each spring, students, teachers and Fellows participate in Science/Math Day at MSU. Students rotate among three sessions: seminars, poster contest and campus tours.

Students attend 30-minute seminars, presented by Fellows and other graduate students, RA's, representatives from STEM industry and minority-serving professional organizations, and international scholars. The seminars present topics that are both interesting and accessible to middle grades students. CSAM faculty share their expertise on cutting-edge research topics such as mathematical modeling of black holes, DNA sequencing, animal behavior, virology, liquid

crystals, applied dynamical systems, geological history of NJ, applied game theory, nutritional biochemistry, meteorite properties, remote sensing, and volcanic processes in the Andes. The goal of the seminars is to show students that cutting-edge research is an extension of their current studies and to promote science and math as worthwhile pursuits.

Student posters are displayed in the Student Center Ballroom. The posters are the culminating project for the middle grades students. In the months preceding the Science/Math Day, classes have worked with Fellows, teachers, and RA's to design and conduct experiments and create their posters. At the poster session, students view the posters and identify the top five from outside their district. Results are tabulated and the ten winning class posters are announced at the end of the day. Photographs showcasing the posters and students are displayed in the schools, the MSU library and on the project website.

The third activity is a campus tour led by CSAM students. Special attention is given to science and computer laboratories and other research and educational facilities. Students learn about the day-to-day activities of college students in general, and more specifically, of science and math students. By exposing the students to STEM opportunities, we are encouraging them to consider pursuing science and math in college and beyond.

Rainforest Videoconference: As part of PRISM's outreach, Dr. Jacalyn Willis leads a team of researchers that hold interactive videoconferences from the rainforests of Panama. She has agreed to annually conduct live videoconferences from the rainforest with each of this project's participating middle schools. Additional field sites for hosting videoconferences are being developed in a cloud forest in Panama, coral reef in Belize, and on a Georgia barrier island. The videoconferences are set within suggested curriculum contexts so that students are prepared in the subject matter and can ask pertinent questions. Professional development for teachers via videoconference is offered to deepen content understandings and suggest field and classroom activities that relate to the videoconference topics. Topics of discussion with scientists cut across habitats with themes such as food webs, energy transfer, biodiversity, and adaptations.

International Components: The project has three international components: Fellow- and teacher-visits to international institutions, visits by international scholars to MSU, and middle school research collaborations.

MSU has ties with institutions that include the Darwin Institute at the Galapagos Islands, Smithsonian Tropical Research Institute in Panama, East China Normal University, Shanghai Normal University, Wonkwang University in Korea and Burapha University in Thailand. We expect that at least four Fellows and four teachers will be selected to visit these international sites for two summer weeks and to collaborate on research and educational projects with international colleagues. For example, at the Smithsonian Institute in Panama, Fellows and teachers would learn about data collection and analysis in long-term wildlife ecology studies that integrate findings on food supplies and population variations. The specific sites and projects are chosen based on the connections between the Fellows' research interests and ongoing projects of international collaborators. As part of their visit, teachers and Fellows have opportunities to visit local schools and interact with teachers.

A formal application process, that includes an essay, letter of recommendation from a colleague, and interview by the PI's are used to select Fellow and teacher participants for this component of the project. RA's, whose expertise most closely matches the objectives of a site visit, work with Fellows and teachers in the month preceding their departure to advise them about various aspects of the research project. Given the short duration of the team's visit, ongoing post-visit communications with the host institution are required. The research experiences of the teams are shared with all Fellows and teachers at a Professional Development Workshop in the fall. The

group generates ideas for the meaningful integration of the international experience into the curriculum units. MSU's Global Education Center is a partner in the international component and has agreed to fund part of the Fellows' travel expenses. School districts have agreed to assist PI's with identifying potential funding sources for their teachers. The Center employs a staff of nine full-time professionals and two full-time administrative assistants who will make all logistical arrangements and introduce Fellows and teachers to cultural and language considerations.

The Global Education Center regularly hosts international scholars at MSU through the *Distinguished International Scholars*, *Forum on International Issues*, and *Visiting Scholars* programs. Each year, participating science or math researchers will be invited to speak at the Science/Math Day about contemporary scientific issues in their countries.

The third component involves pairing selected middle grades classes with classes abroad. Project personnel, such as Drs. Li and Willis, and the Global Education Center have contacts with middle grades teachers in other countries and will assist project directors with matching classes. For example, Dr. Li is in contact with the principal of Beijing San Fan Middle School, a school recognized for its success in science competitions. Together, through communications via teleconferencing and e-mail, each pair of middle grades classes designs and executes a comparative experiment that investigates topics such as air-quality, nutrition, and measuring the size of the earth. Matched teachers share experiences and ideas about middle grades education.

The international components of this project broaden participants' understanding of scientific research, expose them to different cultures, and introduce them to a network of international students, researchers, and educators. Students learn about scientific research in global contexts, and Fellows and teachers have opportunities for extended research and educational work with international colleagues. It is expected that Fellows will become interested in pursuing further international collaborations in their studies and careers.

Benefits

Fellows: Through their work with teachers, colleagues, RA's and middle grades students, Fellows strengthen their communication skills and become more adept at teamwork. They experience the challenges and rewards of contributing to science and math education, thereby becoming advocates of public schools, wherever they are employed. Working with others on the interdisciplinary units contributes to their understanding of scientific research by exposing them to connections among various scientific disciplines. The project introduces them to RA's and STEM professionals who increase their awareness of career options. Their teaching experiences and presentations to colleagues and project staff deepen their understanding of science and math and their own research. The experience of delivering scientific presentations for the general audience prepares them to make formal and informal presentations in industry or academia.

Teachers: Through Professional Development Workshops and interactions with Fellows and RA's, teachers update and increase their knowledge of science, math, technology, scientific methods, and inquiry-based interdisciplinary pedagogy. They learn much of this material in an active hands-on manner, and thus are able to use those constructivist approaches in their own teaching. All districts accept up to 75 continuing education units per year for participating teachers. Rutherford has agreed that the experience meets the district's expectation for teachers to complete one 3-credit course every three years. Kearny will allow teachers to use project work and experiences for salary guide advancement. A part of each teacher's stipend is reserved for travel to conferences to encourage them to become professionally active.

Schools and Middle Grades Students: Schools benefit from having pairs of science and math teachers who have updated and broadened their knowledge of the subject and have been trained on preparing and delivering hands-on, inquiry-based lessons. Students benefit by receiving

enhanced instruction from Fellows—who are models of young scientists—and by participating in the project’s international components. Minority students become aware that incorrectly perceived socio-economic and cultural barriers to their participation in science and math can be surmounted. Schools benefit from the Fellows’ knowledge of content, understanding of research methodologies, awareness of current STEM findings, and experience with using new technologies and laboratory equipment. Other science and math teachers are able to access project-related lessons, activities, and units through the project website. The interdisciplinary units become a permanent component of the middle grades curricula and serve as models of innovative instruction for other schools around the country.

Research Advisors: The RA’s benefit from working with outstanding graduate students attracted to CSAM through this program. They also develop a better understanding of the school science and math curricula that prepared many of their undergraduate students and learn how to identify best practices in local schools. Through their contacts with the school districts they are able to recruit students to CSAM programs.

University: MSU benefits by strengthening its collaboration with area schools and increasing its visibility as an institution with strong programs in science and math. It attracts outstanding STEM graduate students with increased numbers from underrepresented minority groups and increases faculty research, collaboration and external funding opportunities. This cultural change attracts corporate donors interested in supporting science and math education in public schools. Faculty members understand middle grades science and math curricula and develop strong graduate certificate and degree programs in science education that increase graduate enrollments. A graduate-level course, Connecting Mathematics and Science, based on the Summer Institute and the Professional Development Workshops, is developed as a permanent CSAM offering. Graduate students improve their communications skills by presenting their research at the annual Science/Math Day, which also contributes to undergraduate recruitment.

d. Recruitment and Selection

Teachers: Teachers from the five districts constitute the pool of eligible applicants. Each district is assured participation for at least two years of the project; most will participate three or four. Prior to the application process, the PI’s meet interested teachers in their districts and explain the project expectations and rewards. Applicants are required to have at least three years of teaching experience and strong communication skills. The application packet requires teachers to obtain two letters of reference; one from the principal and another from a supervisor or colleague. The recruitment team interviews interested candidates to determine their dedication to working with Fellows and colleagues and to determine if they can commit to all aspects of the program. A total of eight teachers—four science-math pairs—are selected. Districts assist with selecting teachers and identifying science-math pairs and alternates at the same grade level. Three districts have already identified potential candidates for Year 1.

Fellows: Fellows are recruited from STEM students at other institutions and upper division undergraduate and current graduate STEM students at MSU. Recruitment and selection activities occur in the spring semester. At MSU, brochures describing the project are posted in CSAM, especially in the Health Careers office—the minority recruitment and retention program that has made CSAM among the most diverse colleges at MSU. The project is announced in all graduate and upper-level undergraduate STEM courses. Application information appears in the university paper and is announced on its radio station. Notices of the program are sent to all four-year institutions within a 200 km radius of MSU and included with CSAM graduate admissions application packets. Announcements are sent to appropriate job fairs, conferences, and professional organizations. Applications are available in the offices, newsletters, and websites of

The Graduate School, Admissions Office, CSAM, and STEM departments.

All candidates applying to the MSU Graduate School in a STEM discipline prepare a statement of objectives essay and submit GRE scores, transcripts for all undergraduate and graduate work, and two letters of reference. Candidates applying to be a Fellow prepare an additional essay addressing the teaching of middle grades science and math, and submit a total of three letters of reference; including one from a professor that addresses the candidate's capacity to conduct research and another from a job supervisor. Candidates must have a science or math major with a 3.5 GPA and either have been accepted or be concurrently applying to a CSAM graduate program. To strengthen interdisciplinary work in the schools, preference is given to applicants with at least 12 credits in a STEM discipline other than their major.

The recruitment team ranks all applications and interviews the top candidates. During the interview, applicants are asked about their career goals, work with children and anticipated benefits from the program. Ideal candidates understand issues of diversity, have a stated or demonstrated interest in working with middle grades children, believe in the educability of all children, possess a passion for science and math, have adequate research potential, express dedication to working with a team, and can commit to all aspects of the project for two years.

Guided by the discipline of the Fellows and the grade levels of the selected teachers, the recruitment team selects a pool of Fellows and alternates. Fellows are matched with teachers, giving consideration to personality traits, academic strengths, experiences, and interests. Fellows participate for up to two years, with teachers participating for one year to maximize outreach. Selection of Fellows in Years 2 and 4 is necessary only if there is attrition.

Provisions for success with women, underrepresented minorities, and persons with disabilities: Participation by women, underrepresented minorities, and persons with disabilities is encouraged in all recruitment and selection efforts. We will use MSU's student database to identify eligible upper-level undergraduate and graduate students, ask faculty to nominate female and minority students, and send announcements to organizations such as the Association of Women in Mathematics, Graduate Women in Science, Women in Science and Engineering, National Society of Black Engineers, National Society of Black Physicists, Society of Hispanic Professional Engineers, Association of Black Mathematicians, and Society of Women Engineers.

We recently surveyed CSAM students to determine the demographics of a potential pool of candidates. We used our criteria to identify the top 35 candidates, who represented all CSAM disciplines. A high proportion of them were members of minority groups—24 women, 6 African American, 6 Hispanic, and 9 Asian. Because the survey was conducted in a limited number of classes, and only at MSU, we estimate that each year there will be a pool of at least 50 highly qualified candidates that includes members of underrepresented minority groups.

The diversity of the project team, which includes women, immigrants, members of ethnic minority groups, and English language learners, is expected to have a positive impact on recruitment efforts, training activities, and interactions with middle grades students. Students with disabilities are a sizable population in the districts. Dr. David Cooper, the quantitative specialist on the external evaluation team, is a professor of special education at the University of Maryland. He assists in identifying instruments to collect data from this population of students.

The project is expected to attract students who usually do not have opportunities to attend graduate school. MSU traditionally has a large number of students who are first-generation college attendees. This year, 44% of the incoming freshman class indicated they were the first in their families to attend college. Furthermore, historically, only 14% of MSU undergraduate students enroll in graduate school. This project encourages STEM students, many of whom might not otherwise consider graduate school, to apply to graduate programs at MSU.

Project Timeline

Recruitment and Selection (RS) and Preparation: Jan-May

- Recruit, select, match Fellows and teachers.
- Develop Summer Institute (Year 1); revise and refine Summer Institute (Year 2).
- Identify assessment instruments (Year 1); refine assessment instruments (Year 2).

Summer Institute (SI): June-August

- Fellows visit schools.
- Fellows receive training on standards-based instruction and attend LEP/SLD workshops.
- Fellows and teachers attend FOSS/STC/CMP workshops.
- Fellows receive training at field sites on using the sites to promote scientific inquiry.
- Fellows write/revise curriculum units with guidance from PI's and RA's.

Fellows in the Middle schools (FM): September-June

- Fellows observe classes and attend weekly meetings (September).
- Fellows, with teachers, deliver curriculum units, engage students in Field Experiences (October and April) and discuss possible revisions.
- Fellows present and districts review units (December and June).
- Fellows and students participate in Rainforest Connection (January)
- Fellows, teachers and students prepare for poster contest at Science/Math Day (ongoing).
- Fellows present seminars at Science/Math Day (May).
- Fellows and teachers attend monthly Professional Development Workshops.
- Fellows are visited and assessed by RA's (monthly) and PI's (Fall and Spring).

	YR1-2007	YR2-2008	YR3-2009	YR4-2010	YR5-2011
Spring	RS Fellows A	FM Fellows A RS Fellows B	FM Fellows B RS Fellows C	FM Fellows C RS Fellows D	FM Fellows D
Summer	SI Fellows A	SI Fellows B	SI Fellows C	SI Fellows D	Project Evaluation
Fall	FM Fellows A	FM Fellows B	FM Fellows C	FM Fellows D	
Interdisc. Theme	Earth History	Planetary Science	Populations and Ecosystems	Chemical Interactions	
Suggested Field Sites	--School of Conservation --Sterling Mines	--Dreyfuss Planetarium --Essex Env. Center.	--NJ Marine Science --Great Swamp Refuge	--Liberty Science Center --Intrepid Museum	

Assessment/Dissemination:

- External evaluators visit (Spring and Fall Years 1 and 5, annually in spring other years) and provide regular feedback.
- Observe Fellows in the classrooms (September, December, and June).
- Meet with Advisory Board (twice yearly).
- Fellows present their experiences to RA's and project personnel (annually).
- Interview participants and administer survey (pre-test and post-test).
- Prepare annual NSF report (June) and final report (January 2012).
- Give conference presentations and participate in NSF meeting (annually).
- Prepare and submit journal articles and press releases (ongoing).
- Develop new graduate course and seek funding for institutionalization (2009-2011).

e. Organization, Management, and Institutional Commitment

Project Directors: PI Wolff and Co-PI Munakata are project directors. Together, they are responsible for overseeing all elements of the project—recruitment, selection, training, and

evaluation. Both visit Fellows in the classes and meet with teachers, principals, and superintendents in order to assess the project's progress at least twice a year. PI Wolff is responsible for project management and interactions with NSF and the school districts. Co-PI Munakata leads all training and evaluation activities.

Both project directors have experiences related to this project. PI Wolff has outstanding administration skills, and a significant record of university-school collaborations. He has been the PI or faculty on many grants and was the chief architect of the new graduate certificate program and MA in Teaching Middle Grades Mathematics. He teaches mathematics and mathematics education courses at all levels. His research includes the impact of professional development on students and the effective use of technology. His administrative experience includes 18 years as department chair and one year as interim CSAM Dean. Co-PI Munakata taught middle school mathematics for nine years, has an MA in Science Education, and a Ph.D. in Mathematics Education. Her publications include articles about discovery-based learning in science, using field trips to teach hands-on mathematics, and exploring various innovative pedagogies. In addition to teaching mathematics courses, she conducts workshops for middle grades teachers. Recently she taught a doctoral course (developed with PI Wolff) that connects science and mathematics. That course will influence the course being developed for this project.

Advisory Board: The Advisory Board meets twice yearly to review the project. It provides feedback to the PI's about the project and guides the institutionalization of project activities. The Advisory Board includes Deans Prezant (CSAM) and Kaplan (Graduate School), Dr. Srednicki, principal of Faust School (East Rutherford), Ms. Levy, Director of Curriculum (Kearny), Ms. Heinzl, Mathematics and Science supervisor (Rutherford), Mr. Emad Abu-Hakmeh, Mathematics Supervisor (North Arlington), Dr. Geary, Assistant Superintendent (Lyndhurst), and two teachers and Fellows, to be selected each year of the project. Community representatives from industry and minority organizations will be identified to serve on the Board.

District Liaisons: Middle grades teachers Dawn Boyer (math) and Daniel Mazol (science) serve as district liaisons. Their primary role is to work with all five districts to assure that the curriculum units are in line with and can be fully integrated into existing curricula. They also act as the schools' representatives, communicating any concerns that arise at the schools to the PI's.

Recruitment Team: The recruitment team consists of PI's Wolff, Munakata and West and the district liaisons in the first year, and includes an experienced Fellow in subsequent years.

Curriculum Development Team: The three PI's and PRISM director Dr. Willis serve on the Curriculum Development Team (CDT). The CDT guides Fellows and teachers as they develop and refine curriculum units. The CDT consults regularly with LEP and SLD experts, FOSS/STC/CMP workshop leaders, and school liaisons to ensure that units accommodate diverse learners, incorporate inquiry-based science and math instruction, and can be fully integrated with existing middle grades curricula.

Field Experiences Coordinator: Lynn English, Director of the *Weston Science Scholars Program* at MSU, has extensive experiences with using field trips to motivate scientific inquiry. For this project, she works with schools and site representatives to coordinate Fellows' training and students' work at field sites. She also leads writing of field-site-specific instructions included in the interdisciplinary curriculum units.

Science Instruction Coordinator: Dr. Willis coordinates the FOSS/STC workshops and the Rainforest Videoconference. She assists with delivering science education instruction and identifying science assessment instruments.

Evaluation Team: The impact of the project on Fellows, Teachers, students, and faculty participants is assessed using both quantitative and qualitative methodologies. Because activities

involve frequent visits to schools, we have identified internal evaluators to collect and analyze the data, and external evaluators to oversee the evaluation process and interpret the results. Dr. Andrew McDougall, Director of the Statistical Consulting Program at MSU, will analyze the quantitative data. Dr. Sumi Hagiwara, of MSU's College of Education and Human Services, will analyze the qualitative research assisted by a graduate student who collects class observation and interview data. The external evaluation team consists of qualitative researcher Dr. Jim Greenberg and quantitative specialist Dr. David Cooper, both of the University of Maryland.

Administrative Support: To help manage the heavy demands of a project that involves five school districts, 32 teachers, up to 32 Fellows, and over 20 faculty participants, one accountant and one undergraduate student will provide support to the infrastructure of the project.

Project Activities to be institutionalized: By the end of the grant period, an interdisciplinary course based on the project's training activities becomes a part of CSAM graduate programs. The Science/Math Day becomes an annual event, with participation from area schools and presentations made by nominated and selected STEM graduate students. In addition to these project elements, a reduced number of Fellows are supported beyond the grant period.

Institutional Commitment: The high level of institutional commitment to the project attests to the administration's strong support of our efforts. In order to ensure that the Project Directors have adequate time to devote to the project, the University has agreed to allow them to reduce their teaching load to two courses per semester. (The normal load is four courses per semester.) The website for the project is developed and maintained by a Webmaster provided by CSAM.

Realizing the benefits of long-term collaborations with K-12 school districts and permanent implementation of Fellows in the Middle activities, the Provost, Development Department, CSAM Dean, and the Office of Research and Sponsored Programs have agreed to support the project beyond the grant period. MSU's graduate assistantship policy grants a programmatic project of this scale three Graduate Assistants (GA's). The Provost has agreed to "bank" the three GA's and convert them to Fellows in the schools for each of two years starting in 2012. This support, and those described below, provide additional assurances of the institutionalization of the project at MSU. Once the project begins, the MSU Development Office will help seek appropriate funding from local companies to sustain at least four Fellows in each year beyond the granting period. Potential funding sources include Bristol-Myers Squibb, Hoffmann LaRoche, Infineum, Lucent, Merck, Novartis, Turrell Fund, and the Victoria Foundation. MSU has established relationships with these foundations and companies that share our interest in and concern about K-12 science and math education. For example, as noted earlier, Bristol-Myers Squibb funded the development of a Science Teaching and Learning Center that houses PRISM. Additional private support for the science center comes from The Martinson Family Foundation, The Turrell Fund, Hoffmann La-Roche, The Monnell Fund and Verizon. In addition, upon notification of project funding, the Dean will share information about the project with the CSAM Advisory Board and seek their advice and support for project activities. Finally, to provide for project management, training, and evaluation beyond the grant period, the Dean has agreed to a course release and a summer stipend for Co-PI Munakata to train Fellows the year following the grant project. The Office of Research and Sponsored Programs will support travel to conferences to continue dissemination of the permanent components of this project.

Corporate and non-profit cooperation: As corporate partners of PRISM, Verizon supplies all equipment and services for the Rainforest Connection at no charge and Bristol-Myers Squibb sends representatives to middle schools to speak about pharmaceuticals careers. Two of the field experience sites, Dreyfuss Planetarium and Sterling Hill Mines, have agreed to train Fellows, teachers, and project personnel at a reduced rate and provide discounts for field experiences.

f. Evaluation. Evaluation activities monitor project progress, provide feedback to guide our efforts and assess the project's immediate and long-term impact on participants, schools and MSU. The evaluation team and school districts have agreed to comply with all evaluation efforts including the NSF's program-wide evaluation. All assessment instruments are identified and reviewed for compliance with guidelines for research involving human participants by MSU's Institutional Review Board prior to their use.

Fellows: An attitudinal survey, including questions related to career goals, research, and commitment to education, is administered before the Summer Institute and at the end of the school year. Portfolios containing weekly reflections are used to measure changes to Fellows' confidence and teamwork skills. Observations of classes and interviews, conducted before the Summer Institute and before and after the school year, provide additional data to measure changes in Fellows' communication skills, understanding of middle grades students, and commitment to K-12 education. The RA's are interviewed to assess their Fellows' progress.

Teachers: Pre- and post-test comparisons between treatment and control groups on surveys assess teachers' content knowledge and attitudes toward teaching science and math. A graduate student interviews all participating teachers at the beginning and end of the school year to assess changes to their attitudes and comfort with STEM content. Three classroom observations each year reveal changes to teachers' classroom techniques, including their use of the scientific methods, inquiry-based methodologies, technology, and interdisciplinary instruction.

Students: Annual assessments reveal the nature of changes to middle grades students' content knowledge and attitudes toward STEM disciplines. To measure the project's impact on students' content knowledge, comparisons of pre- and post-test results on the Terra Nova science and math assessments are used. The districts have agreed to allow access to scores of *all* students in the schools for multiple years. This allows for formative and summative reports that compare pre- and post-tests between participating and non-participating students.

Additionally, comparisons are made between treatment and control groups on pre- and post-tests that measure student attitudes toward science and math. Instruments adapted from the Fennema-Sherman Mathematics Attitude Scale Short Form (Mulhern & Rae, 1998) are used. In addition to measuring attitudes toward specific aspects of science and math, the adapted instruments include questions that ask students about their 1) attitudes toward inquiry-based and hands-on learning, 2) attitudes toward the use of technology in science and math, 3) understanding of the scientific method, 4) knowledge of the connections between science and math, and 5) interest in pursuing science or math in college and as a career. For all quantitative analyses, we expect treatment and control groups to each have 400 students, for a total of 800 students. This provides a 5% margin of error for within group analysis, and approximately a 3.5% margin of error for between-group analysis of count-based statistics (such as comparison of proportions and chi-square analysis). This sample size will also allow sufficient statistical power to detect meaningful effect sizes using statistical methods such as t-tests and ANOVA. Interviews with 20 randomly selected students from the control and treatment groups at the beginning and end of the academic year add to a more comprehensive analysis. The interview transcripts will be coded and summarized by the Statistical Consulting Program staff.

Project evaluations: At the beginning of the project, Drs. Greenberg and Cooper guide the identification and development of evaluation instruments. After that, they make two site visits annually. Formative evaluations guide the project during the funding period and assist us in developing a sustainable model of the project. Each year, the external evaluators collect data on the number of participating students, Fellows, Teachers, and RA's who are women, members of underrepresented minorities, and persons with LEP or SLD. That data are also used to guide our

recruitment and selection efforts in subsequent years. Additional evaluation data are gathered from annual reports submitted by Fellows, teachers, and RA's; weekly logs written by Fellows; meetings with school administrators; questionnaire results; visits to school sites; and interviews of PI's and RA's. All evaluation results are shared with the Advisory Board. The project collects four years of data by June 2011. Those data are the basis for continued longitudinal studies in participating districts, and for comparisons to the results of the project activities in other districts.

The project results in the inclusion of best practices in STEM instruction and permanent changes to STEM graduate programs at MSU. Related outcomes are measured by ongoing monitoring of the numbers of applicants to STEM programs, minority graduate students enrolled in CSAM programs, graduate students enrolled in the new interdisciplinary course, participating faculty, and corporate partners. The amount and nature of interdisciplinary research at MSU, interdisciplinary connections in courses, communication between teachers and faculty, and understanding of school curricula by faculty will also be assessed annually beyond grant funding.

Dissemination

Reports of project activities and evaluation results are submitted to journals such as *The Journal for Research in Mathematics Education*, *Journal of Research in Science Teaching*, *Astronomical Education Review*, and *School Science and Mathematics*. PI's present ongoing efforts and final results at conferences for the Association of Mathematics Teacher Educators, American Association of Advancement in Science, National Association of Research in Science Teaching, National Science Teacher Association, National Council of Teachers of Mathematics, American Educational Research Association, and the Mathematical Association of America. Teachers and Fellows are encouraged to share their experiences at national and regional conferences.

Because we are recruiting outstanding students to STEM graduate programs, strengthening school-university ties, and institutionalizing the project, some of our dissemination efforts focus on publicizing within the local community. We will write press releases for local newspapers including the Star Ledger, the Montclair Times and the Bergen Record. MSU and district websites will be updated regularly to showcase activities.

g. Faculty Participants. Women and members of underrepresented minority groups are among the faculty members who form the team of RA's. All have an active research agenda, a passion for teaching and positive interactions with students. The RA's and their discipline or department affiliations are: Sandra Adams, Anne Marie DiLorenzo, Chunguang Du, and Scott Kight (Biology); Mark Chopping and Matt Gorrington (Earth and Environmental Studies); Carl Bredlau (Computer Science); Dean Hamden (Physics); Jeff Toney (Chemistry); and Lora Billings, Mike Jones, Mark Korlie, Aihua Li, Arup Mukherjee, Bill Parzynski, Linda Tappin, and Diana Thomas (Mathematics). Each year, based on the Fellows' disciplines, four science and four math RA's are selected from this team. The RA's visit schools monthly, attend presentations by Fellows, and meet and communicate with Fellows regularly regarding their progress and career options.

h. School District Involvement. The PI's have met and collaborated with the school districts to determine project activities, teacher commitments, and district responsibilities. The letters presented as supplementary documentation attest to the districts' strong commitment. The districts will provide release time to teachers to attend conferences and workshops, cooperate on evaluation activities, and assist in the organization of off-campus activities. All districts have indicated a commitment to sustaining project activities beyond the granting period.

Note on resubmission: This proposal, which is based on one submitted last year, has been modified to reflect comments and suggestions from last year's reviewers.