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STEMTEC Grant Proposal Narrative

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Science, Technology, Engineering, and Mathematics

Teacher Education Collaborative (STEMTEC)

1. Overview

High on the American agenda is the need to improve the science and mathematics education of all its children. STEMTEC, the Science, Technology, Engineering, and Mathematics Teacher Education Collaborative, draws on diverse educational institutions committed to providing the next generation of science and mathematics teachers with the knowledge and skills they need. These institutions are also committed to bringing under-represented groups into science and math teaching. They are located in the Connecticut River Valley of Western Massachusetts. A microcosm of contemporary America, this region has prosperous suburbs, but the cities have large numbers of low income minority students, and the rural areas and old mill towns have many poor children. Thus STEMTEC will have a superb laboratory for testing new educational approaches.

STEMTEC will link the members of the highly successful Five Colleges, Incorporated consortium – the University of Massachusetts Amherst (UMass) and Amherst, Hampshire, Mount Holyoke and Smith Colleges – with three neighboring community colleges, Springfield Technical (STCC), Holyoke (HCC), and Greenfield (GCC) and the neighboring school districts. These are the school systems of Springfield, Holyoke, Amherst, Hadley, Northampton, South Hadley, and Franklin County. The partnership of a region's flagship public university campus, private colleges, community colleges and school districts with highly varied populations will provide a model with national implications. The State Department of Education, including PALMS, the Massachusetts NSF/SSI program, will be a participating agency. The Continental Cablevision Corporation will be a corporate partner providing Internet access to area schools and assisting with the dissemination program.

A major component of STEMTEC will be the support of discipline-based curriculum teams which will develop new and revised college science and math courses. In addition to college faculty, these teams will include K12 teachers and education professors who are experts in the new pedagogy. Because most teachers teach the way they were taught (Shymansky, Hedges, and Woodworth, 1990), these courses will model the most effective teaching strategies and tools: cooperative learning, investigation-based teaching, educational technology, new assessment techniques, and opportunities to teach (NCTM, 1991; NRC, 1996; AAAS, 1993). Since the best way to understand the nature of science is to actually *do* real science, we will offer all undergraduates the opportunity to conduct original research. STEMTEC will use these established teaching strategies to reform the way we teach science and mathematics to future teachers.

STEMTEC will serve both elementary and secondary teachers. Elementary teachers usually identify themselves early in their college experience and are generally not planning to major in mathematics or science. Since they will only be taking a few courses in these fields, these courses must provide them with strong content, an opportunity to engage in scientific research, and exemplify the best possible teaching. Math and science majors who already plan to enter teaching as elementary specialists or as middle school or high school teachers also need courses in their major which consciously exemplify effective teaching.

However, many secondary science and math teachers do not decide on teaching careers until college graduation or later. Dramatically improving introductory courses for science and math majors will help to retain them in those areas. It will also interest them in teaching careers because they will become excited about science and math *and* about learning (Tobias, 1990). We will also offer opportunities for college majors in science, mathematics, engineering, and related areas to gain an exposure to teaching by working with teachers who are graduates of our teacher enhancement projects and to consider teaching as a career option. Both the courses and the teaching opportunities

will help recruit under-represented groups into teaching. Inclusion of the community colleges in all aspects of this project will also be critical in these recruiting efforts.

We cannot end our support of students when they enter teaching since we know that many excellent math and science teachers are lost to the field during those first few years. STEMTEC will offer a number of support systems for new teachers including bringing them into the community of school and college faculty developing new courses, linking them with our teacher enhancement graduates, and offering them appropriately scheduled courses which are taught using the methods supported by this project.

The STEMTEC program will include strong student learning assessment, project evaluation, and dissemination components. Much of the program will be exportable, making it an important national model.

Sustainability of the program after the NSF grant ends will be a critical issue. One key is meeting the needs of the participating institutions; what works at one college may not at another. Another is changing the campus culture and extending the process of reform. This will be accomplished by an aggressive program of internal dissemination. Faculty participants will offer departmental seminars and workshops on their course developments and on the pedagogical approaches. Their success in creating more effective courses will encourage their colleagues to attempt their own reforms. STEMTEC will sponsor larger campus-wide and multicampus programs to publicize the course changes, the student responses, and the underlying pedagogical principles and will work with existing campus staff development programs to offer training workshops.

The STEMTEC participants have a long history of collaboration. Over 30 years ago Five Colleges Incorporated, was formed to promote joint activities among the colleges' faculty and students. For example, students may take courses on other campuses as readily as on their own, and free buses make commuting easy. Community college students can automatically continue their

education at UMass upon satisfactory completion of their two year programs, and many community college courses mirror the UMass equivalents. Also, since 1984 the Five College/Public School Partnership (Appendix I) has fostered working relationships among K12 schools and the five colleges. With the aid of several NSF, Eisenhower, and other grants, the Partnership and the campuses have made major strides in improving K12 science and mathematics teaching in the region, emphasizing constructivism, active learning, and alternative assessment methods.

STEMTEC's efforts to improve preservice teacher preparation depend critically on its collaboration with the school districts of the region. This region includes the cities of Springfield and Holyoke, where the school population is 70% minority and over 70% below the poverty level. Franklin County, located in the northern part of the region, is the poorest rural county in the state, with 22% of the students below the poverty line. Amherst, the home of UMass and of Amherst and Hampshire Colleges, has 50% minority students and 25% below the poverty level (Appendix II). Thus the undergraduates who avail themselves of the teaching opportunities will be able to experience many of the difficult issues facing schools across the country.

The program will be facilitated by the existence of a pool of K12 teachers trained in earlier projects who will be a part of STEMTEC, and by the UMassK12 Internet service (Appendix III) which links 2000 classrooms. UMassK12 will continue to be reached initially via modems, with local telephone access available in all the districts. However, over the next few years, Continental Cablevision will phase in free high speed Internet access for all the schools in its service areas, providing a major increase in convenience and bandwidth as the schools install networks.

STEMTEC will be managed by the UMass Science, Technology, Engineering, and Mathematics (STEM) Education Institute (Appendix IV) and by the Partnership, and directed by a Board which includes representatives of the school districts and higher education partners. The program will be coordinated with the systemic curriculum reform efforts being undertaken in the

state under its educational reform legislation and by PALMS; STEM is a PALMS higher education partner, and the Partnership is a PALMS Regional Provider.

2. Needs

Since the early 1980's there has been broad agreement that the U.S. must improve the science and mathematics education its school children receive (NCCE, 1983). Reports emphasize giving students the opportunity to think like scientists (NCTM, 1991; NRC, 1996; AAAS, 1989, 1993). They stress the importance of creating an environment in which students are engaged in long-term investigations and cognitive problem solving. Ultimately this improvement can happen only if teachers have a better knowledge of the content and pedagogy of these fields. Much effort has been focused on strengthening the qualifications of teachers now in the schools, and in helping them to adopt new and more effective teaching approaches. In Massachusetts, the Education Reform Act of 1993 legislated a comprehensive program that significantly increased financial support to the schools, required the development of curriculum frameworks consistent with the national recommendations, and mandated periodic recertification of teachers (Massachusetts Department of Education, 1995). It is the responsibility of the higher education community to reinvent their teacher preparation programs so that teachers entering the profession have the requisite science and mathematics preparation (Glass, Aiuto, and Anderson, 1993).

Four specific areas of need will be addressed by STEMTEC:

- Future elementary teachers—expected to be renaissance scholars capable of teaching every subject—need to experience science and mathematics courses that model the best teaching practices. They need inquiry-based courses which incorporate cooperative learning and employ

modern technology to enhance understanding (NCTM, 1991; NRC, 1996). They also need to experience science by engaging in original research (NRC, 1996).

- At the middle school and high school level, we are seeing shortages of qualified science and mathematics teachers and elementary science specialists both locally and nationally (Weiss et al., 1994). Thus we need more as well as better prepared secondary teachers. Qualified teachers can be recruited from those who are currently majoring in science, mathematics, engineering, and related fields, or who have completed programs in these areas.
- Many minority groups continue to be under-represented in science and mathematics education (Oakes, 1990). Nationally, 30% of the students belong to under-represented minority groups, but less than 10% of the science and math teachers are from these groups. (Weiss et al., 1994; NCES, 1994). Over the past 20 years the number of women teaching secondary mathematics has increased to approximately half the total, but only a third of the high school science teachers are women. The Massachusetts statistics are similar to the national data (MA Dept. of Ed., 1996). We need to recruit and retain women and minority students in the appropriate college majors and into teaching.
- Too many newly certified teachers find themselves very much alone in their early teaching years as they learn how to cope with practical classroom issues while honing their teaching skills. We need to develop mechanisms to provide them with the support they need.

3. Project Goals

STEMTEC's fundamental objective is to improve science and mathematics teaching in the schools by educating a generation of teachers who are better prepared in the content and pedagogy of these fields. STEMTEC will also contribute to the important task of elevating the status of teaching as a profession on the campus and in the community. The programs we discuss below are designed to meet the specific goals, but they will also contribute to a broader agenda of changing the campus

culture and reshaping how we teach science and mathematics to all students. The following specific project goals address the needs of the future teachers who will teach science and mathematics at all grade levels:

1. Assist college science, mathematics, and engineering faculty in learning and adopting new pedagogic approaches, especially in courses for future teachers.
2. Improve the preparation of elementary teachers to teach science and mathematics.
3. Improve the preparation of middle school science and mathematics teachers and of elementary school science and mathematics specialists.
4. Increase the exposure of majors in science, mathematics, engineering, and related fields to teaching experiences and the possibility of teaching as a career and to increase the number entering the teaching profession.
5. Increase the number of women and minorities—high school students, college students, and returning students—preparing to be science and mathematics teachers, especially those living in inner cities and in poor rural areas.
6. Develop a program to support new science and mathematics teachers in their first years in the classroom.
7. Document and disseminate the program nationally.

Achieving the project's goals requires a variety of related efforts which will be covered in turn in the following sections.

4. Teaching Strategies

STEMTEC will recruit and support curriculum teams to develop new and modified science and math courses. These will employ cooperative learning, investigation-based teaching, educational technology, new assessment techniques, and opportunities to teach. All five approaches provide

opportunities for active learning, and are solidly based on experience and educational research. Underlying these approaches is the concept of *constructivism*: students come with a set of experiences and cognitive structures through which they interpret their environment. If new information is to be part of a learner's framework, and not added on and easily forgotten, the learner must fit this knowledge into his or her existing framework.

4.1 Cooperative learning

Students working in groups mirror the way much work is done in the world of science and business. They clarify their own thinking by explaining their ideas to their colleagues, and they benefit from the latter's thoughts and knowledge. Cooperative learning is a very effective active-learning approach that works, for example, in dealing with misconceptions. Students come to our courses with many misconceptions about the natural world (e.g. carrots in the grocery store are not alive or in summer the earth is closer to the sun). Those who take traditional lecture style courses often retain misconceptions of concepts directly dealt with in the course (e.g. Holloun and Hesternes, 1985; Mestre and Touger, 1989). Cooperative group learning is one effective way to change misconceptions (e.g. Dufresne et al., 1996; Heller et al. 1992; Heller and Hollanbaugh, 1992) because when students interact with each other, they experience internal conflicts that force them to reexamine their understanding of an idea (Lord, 1994; Duckworth, 1987). Dr. Jose Mestre from UMass is a leader in this field and will work with the curriculum teams.

4.2 Investigation-based teaching

Students will have a range of investigation-based educational opportunities, ranging from inquiry-based teaching in more conventional courses to research-based courses. Faculty will use different models depending on the course goals. They will guide students (*guided-inquiry*) by giving them starting questions or prompting new directions with ideas and methods. Students may also conduct *open-ended* inquiry-projects. Here, the teacher acts as a facilitator for students who do the

research as independently as possible (D'Avanzo and McNeal, in press). In the *teacher-collaborative* research the teacher works side-by-side with the students as a co-researcher. These investigations are "genuine" because the question is of interest to the research or general community, the outcome of the project is unknown to the students *and* to the teacher, and so the class is doing real research.

Investigation-based teaching is consistent with the recent reform efforts calling for changes in both what we teach and how we teach science (NRC, 1996). There is a new recognition that inquiry- is central to the process of science as well as to the learning of science. The best way to prepare future teachers is for them to do scientific research as undergraduates. Teachers are poorly prepared to teach students the process of science if they have not experienced it themselves.

In research-based courses students are scientists. They ask questions based on their own observations, interests and insights. They design experiments and collect and analyze data. They revise hypotheses and experiments in light of new data. In the process, undergraduates gain important insights about what science is (and what it is not) which they can pass on to their own students: 1) they gain a clear sense of what it means to *do* science - that it is a *process*, 2) they understand that science is fundamentally a way of satisfying one's curiosity about how the world works and not primarily about knowing things that others have discovered, and 3) they understand why data and quantitative analysis are important and develop the ability to think intelligently using quantitative logic. STEMTEC's courses will make use of inquiry-based teaching, which is directly related to constructivism because learners actively construct their own knowledge. College faculty will learn how inquiry-laboratories are used in traditional courses such as introductory biology (Lawson, et al., 1990; Sundberg and Moncada, 1994) and in entirely project-based courses (D'Avanzo, 1996; D'Avanzo and McNeal, in press) and will apply these models to their own classes. The courses will also include new kinds of inquiry-based labs with applications of educational technology such as *BioQUEST*.

Students in our program will also have a range of research-based courses to choose from. These courses will be discipline-based for science and math majors and interdisciplinary for both these students and prospective elementary teachers. Some models already exist: The Human Skeleton (focus is bones and disease; Hampshire), Hydrology (groundwater; Smith), and Unity of Science (interdisciplinary; Mount Holyoke). STEMTEC will establish research-based courses on other campuses and in other fields.

4.3 Educational technology

Integrating educational technology with more traditional instruction in college science and math courses will improve student learning and also model its use in the schools. It will be a major priority for STEMTEC. A variety of technological tools will be used; for example,

- Graphing calculators have revolutionized mathematics teaching by making it easy for students to visualize complex figures and surfaces and to see how they change with the parameters.
- Microcomputers can help students to collect, analyze and manipulate experimental data, display it in a variety of graphical forms, and explore the patterns and relationships among the variables.
- Electronic feedback via *Classtalk* facilitates active-learning in large lecture classes by allowing students to transmit responses to the instructor's work station for analysis and display.
- Multimedia technology is used at STCC by faculty to enliven classroom presentations. At Smith, it has been found that collaborative student efforts at multimedia authoring lead to new ways learners look at science and research as they are challenged to integrate their work with others and to create group presentations to be shared either locally, or globally via the Web.
- Video opens up many opportunities for students to develop their understanding. The instructor can slow down the flight of a projectile or motion of an athlete, analyzing it frame by frame, or speed up the germination of a seed. Better yet, students can define their own questions and use a camcorder to find the answers and assess their understanding.

- Intelligent multimedia tutoring systems being developed by the UMass Computer Science Department model real world systems and enable the student to test ideas and ask questions. Examples:
    - The *Advanced Cardiac Life Support Tutor* simulates cardiac arrests and teaches specific treatment protocols when the learner reaches the point where they are needed.
    - Engineering students learning about injection molding, stamping and finite element analysis design, build, and rotate pieces in 3 dimensions. The tutor advises them about the difficulty or expense of manufacturing the piece based on their design. 3D animations illustrate the tooling that will be required to create the part from the student's design.
    - *Gaining Confidence in Math: Intelligent Tutors for Girls and Women*, an NSF funded project, will create math software designed to instill in grade school girls confidence in their math problem solving skills. Two STEMTEC elementary schools are partners in this project.
- Internet technology is increasingly important, and will be built into many of the new courses. We are at the start of an era in which computers and television will be integrated in our schools, homes, and workplaces. At present, all but a very few schools are limited to accessing the Internet via modems, a connection model which is inherently too slow and too expensive for widespread use in a school. However, this is changing rapidly in our area. The Continental Cablevision Corporation is upgrading its network so that each home will have available at an affordable cost a 10 Mb Internet connection — several times the current total UMass capacity — and each school will be able to connect its network to the Internet without cost. As we know from our experience with the UMassK12 Internet Service (Appendix III), science and math comes alive as students get weather maps, earthquake data, and other real time information via the web and communicate with people around the globe.

4.4 New assessment methods

Appropriate assessment techniques will be important in the new and revised courses developed by STEMTEC. It has been our experience that school and college faculty who incorporate student-active learning tend to return to their traditional lecture-based teaching over time because they do not receive appropriate feedback on their students' conceptual and skill development. Most faculty are alone in their classrooms and they need continuous reinforcement that their new approaches are working and that students are learning. There are many proven alternative assessment methods appropriate in courses where students are active learners: portfolios, exhibitions, group exams, students writing questions for each other, and journals (Angelo and Cross, 1993). Courses developed by STEMTEC will have suitable assessment methods built into their design.

4.5 Teaching opportunities

Having college students teach will serve three purposes. It will improve their own understanding of the material and the learning process, it will expose them to the possibility of teaching as a career, and it will represent a service to the community. STEMTEC is especially interested in using teaching experiences as a way to recruit science and math majors into teaching at all grade levels. In addition to stand-alone activities, teaching opportunities can be incorporated into regular college science, engineering, and math courses. Ways to create these opportunities will be explored in the Summer Institute discussed in the next section.

5. Curriculum Development

STEMTEC's largest task is the development of college courses designed to accomplish the project's goals. These courses will be developed by science and math faculty from the eight participating colleges working in curriculum teams to develop or modify introductory and more

advanced courses for their respective institutions. The goal is to develop programs that meet the needs and resources of the colleges, so that these courses—and the process of reform—will be continued after STEMTEC has ended. There will be curriculum teams of about 7 or 8 people in biology, chemistry, geology, mathematics, physics, educational technology and interdisciplinary research. Each team will have faculty representatives from several colleges, two K12 teachers who are graduates of our teacher enhancement projects, and an education faculty member. One member of each team will serve as a chair.

Summer Institutes are a cornerstone of the curriculum development effort. They will allow for concentrated efforts by the teams and for the exploration of the new pedagogical approaches. A key goal is to modify faculty attitudes about teaching and learning in ways that result in significant changes in course structure and goals and ultimately in student performance. There will be two cycles of curriculum teams, one starting in 1997 and one in 1998. Each cycle will last three years and have 40 college faculty; there will be 12 from UMass and an average of 4 each from the other seven colleges.

In the first summer, participants will devote two weeks to a Summer Institute and a minimum of one additional week to the project. In addition to the Summer Institute support, the project will offer financial assistance for course development. This will average $11,000 per course for teaching assistants, released time, technical or programmer support, additional summer compensation, etc. Each team will design its academic year follow-up program including Internet exchanges, visiting each other's classes, and get-togethers. These important activities will allow faculty opportunities for reflection, help when problems arise, and mutual support. There will be one week Summer Institutes in each of the two following summers, and a midyear meeting of all the STEMTEC participants in addition to the meetings planned by the individual curriculum teams. Some new and modified courses will be offered in the academic year following the first Summer Institute, but the lead times

associated with registration or the need for additional curriculum development will postpone other courses for a year.

The schedule for the two week Summer Institute is shown in the following table:

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
AM	cooperative learning	investigation	technology	technology	team planning
PM	review curriculum and local case studies	continue review	explore course options	initial planning	cross-team meeting
Week 2					
AM	assessment	teaching opportunities	women and minorities	workshops as needed	team planning
PM	team planning	team planning	team planning	team planning	interim team reports

Mornings will be devoted to workshops for everyone on the teaching strategies; the workshops will be led by science faculty who have successfully implemented the reform of science and math courses. Afternoons will be devoted to work in the curriculum teams, in subgroups, or individually. The curriculum teams will consider how the various teaching strategies can be used effectively in their areas. They will also examine local course models that work well, curricula developed by professional societies or under the auspices of NSF (e.g., *Physics by Inquiry, Powerful Ideas in the Physical Sciences, Chemistry for the Information Age, BioQUEST Curriculum*), and the several studies from the National Center for Improving Science Education. The faculty will develop courses for their institutions which incorporate learning approaches appropriate for future teachers and will also serve other undergraduates better than the existing lecture oriented offerings. Changing courses to reflect our current understanding of how students learn and making that process more apparent will be valuable both in improving student learning and in motivating future teachers.

After the Summer Institute, participants will spend at least four days working individually or in small groups. They will all meet for one day at the end of the summer to share their progress and to finalize academic year team activities.

The one week summer workshops in the second and third years of the cycle will reunite the participants for exhibitions and informal exchange. They will give faculty the opportunity to reflect collectively on their efforts, learn from each other, be recharged by the group's enthusiasm, refine their courses, and plan local and national dissemination efforts. The local dissemination is critical in establishing a permanent process of educational reform. Participants will plan presentations for their professional colleagues showcasing their courses, the student responses, and the evaluation data.

6. Impact on the Preparation of Elementary Teachers

Prospective elementary teachers seldom major in science or math and their only exposure to these areas is often just one or two introductory courses. Many of these courses are large, and if there is a lab, it is often of the cookbook variety. It is critical that these courses be redesigned to incorporate new pedagogical techniques to ensure that the learning experience is a positive one and it models the teaching practices that we hope to see in the schools. We need to instill confidence in these students in their ability to learn science and math and to teach it, as well as providing a real understanding of the nature of these fields. The fact that prospective elementary teachers usually decide early on a teaching career makes it straightforward to guide them into the appropriate courses once they are available. The teacher education advisors will work with STEMTEC to insure that this does happen.

6.1 Revised general education courses

A principal STEMTEC goal is to develop course materials and learning strategies to enrich introductory courses in all scientific disciplines and mathematics for future teachers. Courses developed by the curriculum teams will employ the five teaching strategies we have discussed and

move from a lecture mode towards an inquiry-based, interactive format to stimulate students interest and encourage them to explore courses in other scientific disciplines. Other students will also benefit from the course changes, and they may become interested in the teaching profession. The methods used to improve these courses apply equally well to introductory courses designed specifically for science, mathematics, and engineering majors. Specific techniques are illustrated by the following examples:

- Systems that enable the professor to better monitor student comprehension. *Example: The Classtalk electronic feedback system at UMass.*
- Development of new multimedia materials for integration into the lecture-discussion format. *Example: STCC's multimedia classrooms and labs.*
- Incorporation of computer technology to drive self-study modules and intelligent tutoring systems. *Example: The UMass introductory chemistry courses have reduced dropout rates by making extensive use of self-study modules in place of the conventional discussion sections.*
- Conducting exercises and investigations during class time which involve teamwork and cooperative learning. *Example: Smith's Intensive Calculus with Discrete Mathematics*.
- Providing a research framework as an option or a requirement to encourage students to design and carry out their own research projects. *Example: All Hampshire College freshmen must complete independent scientific research projects.*
- Including teaching and community service activities. *Example: Amherst College chemistry students focus on water quality issues in the community.* Such experiences are especially good at motivating women and minority students who often are encouraged by seeing the community implications of their studies.

6.2 Courses specifically for elementary teachers

STEMTEC will develop courses aimed specifically at preservice elementary teachers. At UMass, about 80 early childhood and elementary teachers are graduated annually, so it is economically feasible to design introductory courses specifically for this audience. There is also the opportunity to create special sections of larger courses tailored to their interests. Two courses for elementary teachers have been tested recently at UMass; each was well received and will serve as a model:

- In the Spring, 1996 semester, *Electricity and Magnetism* was offered for 20 undergraduates and 10 inservice teachers and graduate students. It was taught by a physics professor, a high school physics teacher, and a K-8 science specialist. Based on the NSF/Operation Physics workshop materials, the course encouraged students to ask questions, design experiments, and analyze and reflect on their results. It also considered classroom implications and the Massachusetts Curriculum Frameworks.
- For several years *Using Insects in the Classroom* has been offered to classes including preservice and inservice teachers. Developed by a UMass Entomology faculty member in collaboration with a school elementary science specialist, it blends basic science with classroom issues. This course will shortly be broadcast statewide and nationally by Massachusetts Corporation for Educational Television.

6.3 Interdisciplinary research and educational technology courses

We have discussed the power of research-based general education courses in which undergraduates have the experience of being research scientists, and the need to create new interdisciplinary research courses. STEMTEC will develop interdisciplinary research courses which will be team-taught by science, math and engineering faculty who will help students plan and carry out short research projects of their own design. The level will be suited to general education students

so that minimal background in science or math will be necessary. Students often have a false sense of how science originated because of the artificial boundaries between scientific disciplines in our academic structure. Providing interdisciplinary research courses will ameliorate this problem. An additional advantage of making them interdisciplinary is that students who are typically less fearful of biological subjects than the physical sciences and mathematics will get some introduction to the latter.

The importance of research experiences for teachers was demonstrated to us in the NSF/5C5E project (ESI-9150262) for middle-school science teachers (Wilson and Sternheim, 1996). Teachers were introduced to scientific research in areas related to the Earth's environment and received minimal content-based preparation. The focus was on research strategies, methodologies and data interpretation, and the participants applied these to their own projects which they carried out with their classes during the school year. We were impressed with the results and the enthusiasm with which the school-year projects were conducted as well as with the continuing research projects being conducted in those classrooms. STEMTEC will assure that all future elementary teachers on all the campuses have this opportunity.

Educational technology will be an integral part of the courses in order to enhance student learning and to model its pedagogic uses. Also, a course in educational technology will be developed for future elementary teachers. It will draw on the expertise of faculty in science and math as well as education and computer science. Multimedia authoring and Internet applications will be emphasized.

7. Impact on the Preparation of Middle-School Teachers and Elementary Science/Math Specialists

Massachusetts certification requirements for a middle school science teacher include either a major in a specific science or a set of introductory courses plus more advanced courses in two or

more departments. The latter interdisciplinary model fits the contemporary middle school curricula which touch on all the sciences in a single course and integrate science with other subjects in a team teaching environment.

UMass has an existing Science Major intended to provide this background, but few students elect it because the requirements are more numerous than for conventional departmental majors. As a byproduct of the work on this proposal, a committee has proposed reducing the requirements, and positive action is likely this fall. When that happens, we anticipate a large increase in enrollment among students who decide not to pursue professional careers in science, mathematics, and engineering. Every year large numbers of students drop out of these fields and switch to nonscience majors. An appealing Science Major will attract some of these students to middle school teaching. This major will also be an attractive option for students who begin or restart their college education at the community colleges.

Depending on the department and college, prospective middle school teachers will take either the introductory courses discussed in Section 6 or the courses for science and math majors discussed in the next section. STEMTEC will develop educational technology and interdisciplinary research courses that are similar to those for elementary teachers but reflect the stronger content background of this group. These courses will also serve many majors in the individual sciences or mathematics.

In Massachusetts, prospective elementary teachers may no longer major in education; they must have a content area bachelor's degree. Currently most of these students major in English, history, or a social science and few major in science or math. The Science Major would be an excellent choice for future elementary teachers, especially the future science or mathematics specialists or coordinators.

Although similar Science Major programs are not offered at the other colleges, students have the flexibility of proposing an interdisciplinary major, and the Science Major can be used as a model for prospective middle-school teachers for all members of the collaborative.

8. Impact on Recruiting Science, Math and Engineering Students into Teaching

The option of teaching in the nation's schools is seldom presented to declared majors in the scientific disciplines or math. Most students who seek secondary science or math teaching certification do so late in their undergraduate careers, or return to school after graduation. STEMTEC will help them to make the connection earlier by modifying introductory and upper-division courses as well as offering teaching experiences. Also, the colleges have special tracks and programs for talented students (Honors Program, Talent Advancement Program) which we will target for special recruitment. The goal is to ensure that the brightest students interested in the these areas know the opportunities and rewards of teaching.

8.1 Introductory courses

The pedagogic strategies discussed earlier in the context of general education courses for elementary education students and other non-science majors apply equally well to the introductory courses designed for majors in science, mathematics, and engineering. There are, of course, significant reform efforts already underway. For example, at UMass the lab for the large physics course for engineers is being redesigned; the lecturers in this course and in the introductory sequence for physics majors are experimenting with the *Classtalk* system mentioned earlier. Also, UMass has just hired new faculty members in Chemistry and Biology to integrate educational technology into introductory courses; these faculty will participate in the curriculum teams. STEMTEC will provide

the resources to expand these reform efforts to other courses, both within those departments and elsewhere on the campuses of the participating colleges.

8.2 Modifying upper-division courses.

The curriculum teams' goal will be to assure that all science and math majors have at least one required course that employs the five pedagogical strategies we have described and that explicitly discusses the learning process. Examples of these how these strategies can be used in upper-division courses include:

- *Cooperative learning*. Make laboratory and field projects a team effort instead of a competition for the best grade.
- *Inquiry-and research*. Have a portion of the course be a research project with significant student input in the design and execution of the research. In some departments only honors students get this opportunity; all students should have a research experience.
- *Incorporation of educational technology*. Design software modules that students can use in self-paced study and review and have students design modules for others.
- *Appropriate assessment*. Incorporate frequent, simple techniques that provide both faculty and students with information on student learning.
- *Teaching experience.* Incorporate a requirement or an option that provides a teaching experience. (See examples below.)

8.3 Teaching Experiences

STEMTEC will offer college and school teaching experiences as parts of regular courses, volunteer activities, and special seminar courses. These experiences will be facilitated by campus coordinators at each college, in most cases an administrative staff member, who will also be responsible for the general operation of STEMTEC on that campus; a science or math education graduate assistant will coordinate UMass teaching experiences. The coordinators will meet with some

of the college faculty and with ten school teachers who will serve as mentors during a three day meeting overlapping with the first Summer Institute to plan for the first new efforts in this area. Full implementation with fifty mentors will start in the second year.

Undergraduates will have the opportunity for teaching experiences both at the college and school level. They will be able to teach and tutor in the introductory level college science, mathematics, and engineering courses. There will be opportunities to help develop lab experiments or educational software. Experiences as teaching assistants have been an entry into teaching for significant numbers of secondary school science and mathematics teachers. Giving them this opportunity early on will encourage more undergraduates to consider teaching as a career.

At the school level, college students will do tutoring, advise science clubs, serve as mentors via email, or teach a lesson. The following existing programs in the participating colleges will serve as models, but it will be important to substantially increase the number of students who participate:

- At Smith, *Intensive Calculus with Discrete Mathematics* requires college students to teach lessons at a school to "learn the difficulty of communicating mathematics to others, and the joy of seeing in someone's eyes the thrill they get when they suddenly understand something you are trying to communicate."
- Also at Smith, a January Internship exposes students to the rewards and excitement of classroom teaching. Students are chosen on basis of commitment and their proposed teaching plan, meet their host teachers in December, observe one day and teach/plan/observe four days in January.
- At Hampshire, students staff an inquiry-based *Day-in-the-Lab* for Holyoke middle school students, organize after school clubs, and serve as mentors via email.
- At UMass, students tutor children in Springfield and Greenfield schools.

- At Amherst, students in *Women and Minorities in the Sciences* work with elementary schools to incorporate science experimentation in the curriculum, and author teaching packets on the contributions of women and minority scientists.

Because we are focusing on science and math majors who are not presently planning to teach, we need to provide them with some guidance in order to make their teaching experience successful. We will develop workshops which prepare students to advise after-school science, math, or engineering clubs; act as teacher aides or tutor individual students; and engage in email conversations with school students. Students will have the opportunity to engage in "drop-in" programs of several days to a week to implement special projects in science, mathematics, or engineering. Close contact between the colleges and schools in the implementation of the field experiences will ensure the symbiotic relationship in this collaborative. Undergraduates will be selected to participate, and the workshops will prepare them by introducing constructivist forms of pedagogy and by helping them to be aware of the needs of diverse student populations. The students will be supervised while in the field by the mentors, and write reflective papers about their experiences to be shared in a poster session for other undergraduates, college and school faculty and administrators, and the public.

The mentors will have key roles in this program. It is their classrooms which the students visit and they will ensure a supportive climate for these visits. We are fortunate to be able to draw on the more than 400 graduates of our teacher enhancement projects. These teachers are an important resource because they already have been exposed to the new forms of pedagogy and assessment. Ten teachers in 1997, and 50 in subsequent years, will be identified annually as mentors and engage in professional development activities that will hone the skills they developed in earlier programs, and will prepare them to be effective mentors for undergraduates. Mentor professional development activities will take place during the summer (3 days) and continue through the academic year. These mentors are in addition to the teachers who will serve on the curriculum teams.

The mentors and advanced graduate students in science and math education will work with the campus coordinators to facilitate the field placements and to teach the workshops in which the undergraduates will be enrolled. These teaching experiences will have several desired outcomes. First, undergraduates will have the opportunity to experience classroom teaching which may lead them to choose teaching as a career. Second, school children will see that undergraduates have an interest in teaching, encouraging them to think about becoming teachers. Third, the interaction of teachers, mentor teachers, undergraduates and advanced teacher education students will result in the improvement of the teaching and learning of science and mathematics in the schools as these teams work collaboratively. Finally, special efforts will be made to encourage women and minorities to join in this program. This will encourage these undergraduates to consider becoming teachers, and it will provide women and minorities as role models in the sciences and mathematics for school students.

9. Supporting New Teachers

Even with exemplary preservice teacher education, new teachers find the first few years in the classroom to be trying experiences. To better ensure the success and retention of new teachers, STEMTEC will provide support to new science and math teachers in the participating schools districts; some but not all of these teachers will have received their educations in the participating colleges. The program is designed to implement the state-mandated Standard Certification process which, as a result of the 1993 Education Reform Act, must be completed within five years of initial certification. STEMTEC will work closely with the faculty in the colleges that have Standard Certification programs and will provide new science and math teachers with the following resources:

- Internet accounts on UMassK12 for access to the STEMTEC Teacher ListServ and web page, which will be visited by new teachers, mentors, and college faculty.
- New teachers will be paired with STEMTEC mentors for ongoing support.

- Selected advanced science and mathematics courses, which employ the modern teaching strategies and meet the requirements for Standard Certification, will be offered at times convenient for teachers.
- A new course, Teaching Science and Mathematics in Schools, to be part of the Standard Certification program at UMass, will be developed in the School of Education to provide new teachers with a seminar focusing on pedagogy, curriculum, and assessment within the context of the reform efforts. All aspects of the course will directly relate to the teachers' current practice.
- New teachers will be provided with the opportunity to observe each other teach.

10. Increasing the Number of Women and Minorities

As noted earlier, we need to bring more minorities into science and math teaching and more women into science teaching. The participating colleges presently certify approximately 330 teachers annually; 82% are women, 8% are minorities, and 16% are in secondary math or science. The efforts to attract science and math majors into teaching should increase the number of women entering those fields, especially at Smith and Mount Holyoke, which are women's colleges. Collaborations with the area community colleges and high schools will focus on attracting more minority and poor students to enter these areas and will build on programs already in place. NSF has indicated that $100,000 per year will be available for scholarships in the second through fifth years for programs such as STEMTEC. This will enable us to recruit and support forty minority students from the community colleges to continue their preparation as science or math teachers. We will work with the college development officers to fund this program after the grant ends.

The revised science and math courses in all the colleges with their emphasis on cooperative learning are likely to attract and retain more women and minority students. This has been demonstrated in several studies (Posaner and Markstein, 1994; Sullins et al., 1995).

10.1 The role of the community colleges

STEMTEC will build on existing collaborations with Greenfield (GCC), Holyoke (HCC), and Springfield Technical (STCC) Community Colleges. Their students are primarily working, non-residential commuting adults, attending part time and often in the evening, mostly minority and/or female; STCC has 27% minority students, HCC 20%, GCC 6% (Appendix II). They have strong relationships with the schools through School to Work, Tech Prep and 2 + 2 programs, and participate in a Joint Admission program which guarantees qualifying students admission to UMass. They have a strong record of success in helping students from under-represented groups to prepare for a wide range of careers.

The community colleges will be full partners in STEMTEC. Their faculty will be members of the curriculum teams and will develop courses that fit the community college environments. Adding a science and math teaching option fits naturally into their agendas, since students interested in these fields need to see a clear career track. An increasing portion of community college staffs are part-time adjunct faculty without long term contracts; some departments depend on adjuncts for over a third of their teaching. Their presence underscores the need to make course revisions and develop reform agendas which will be adopted by the institutions and be independent of the particular faculty members.

STCC, UMass, and the Springfield Schools are in the process of developing a program to provide access to teacher certification for African-American and Hispanic women who are employed as elementary school teacher aides. They will take the STCC transfer curriculum which parallels the first two years of the UMass curriculum. The UMass Science Major option (Section 7) will open the opportunity for the aides and other students to become middle school science or math teachers or elementary science/math specialists. STEMTEC will use the NSF Scholarship money to assist some of these students. Similar cooperative programs will be developed with HCC and GCC.

10.2 Coordination with existing school programs and guidance counselors

STEMTEC will take advantage of existing middle and high school programs to encourage women and minorities to consider becoming science and math teachers. All the colleges are currently involved in programs that connect directly to school students. These include Upward Bound (UMass, HCC), TechPrep West (HCC, GCC, STCC), the Science Enrichment Program (UMass), and the Skills Training Enrichment Program for middle school students (HCC); Hampshire is helping to develop the curriculum for Springfield's new Science and Technology High School. The directors of these projects, some of whom are directly connected with STEMTEC, will be urged to include activities in their programs that demonstrate the attractiveness of teaching as a career for women and minorities. In addition, STEMTEC will host a series of informational meetings for guidance counselors from the participating school districts to provide them with information about career opportunities in science and math, including teaching, for all students, and especially women and minorities. This program will be modeled on Smith College's *Present Students, Future Scientists and Engineers Program* which works with science and math teachers and guidance counselors.

10.3 Teaching experiences for high school students

Although STEMTEC focuses on college students, we recognize that career planning starts at a much earlier age. Accordingly, the project will pilot parallel initiatives in two high schools — the new Springfield Science and Technology High School, and Greenfield High School. In each of these two schools, high school students will be given the opportunity and encouraged to tutor other students, to serve as teaching assistants, and to mentor middle school or elementary school students. These experiences will be facilitated by a teacher at each of the high schools and at the middle or elementary schools. The four teachers involved will take part annually in the summer workshop for mentors, and will meet regularly with the coordinators of the parallel college activities. We will track the participants to determine how such teaching experiences influence high school students.

11. Project Management

The various parts of STEMTEC will be under direct administrative supervision of the STEMTEC Council. Day-to-day operations will be centered in the offices of the STEM Education Institute and the Five College/Public School Partnership.

- **STEMTEC Board:** Basic policies will be set by the Board, composed of the PI's, representatives of the school districts, higher education partners, Continental Cablevision, and PALMS (the state SSI program). It will meet at least twice each year.
- **STEMTEC Council**: The PI's will meet regularly as the Council to review all aspects of the project, assess progress, plan for the next phases and make ongoing adjustments as required. PI *Sternheim* will take the principal responsibility for monitoring all project activities. He will also be responsible for overseeing the technology components of the program.
- **Curriculum Committees:** Each curriculum committee will have a chair who will schedule its academic-year sessions, track the progress of the committee members, and prepare summary reports of the changes and revisions incorporated into the courses and curricula. The chairs will meet monthly as a Coordinating Council chaired by Co-PI *Yuretich* which will ensure that the revisions in the undergraduate programs are proceeding in accordance with STEMTEC goals.
- **Teaching Experiences and Mentoring:** Co-PI's *Feldman* and *Wilson* will be responsible for supervising the development of teaching opportunities in the colleges and the schools, as well as recruiting and working with the mentor teachers.
- **Evaluation and Assessment:** Evaluation and assessment will be carried out at several levels by an integrated team directed by the Donahue Institute. The evaluation, which is described in detail in Section 14, will focus on summative and formative evaluation of two major areas: course reform and teacher recruitment. Summative evaluation will be done primarily by the Institute. Formative evaluation will be done by members of the team who can remain in close contact with

teachers and students in the project. *Dr. Eric Heller*, Director of Research, Evaluation and Information Technology at the Donahue Institute, will oversee the design and implementation of the evaluation plan. He has extensive experience over the past decade in program evaluation for a broad range of client groups and substantive domains. As an organization reporting to the President of the five UMass campuses, the institute is positioned to perform an independent summative evaluation of the project, and yet is physically located at the Amherst campus. *Dr. Mary Dean Sorcinelli*, Director of the UMass Center for Teaching, will oversee the standard formative evaluations of the reformed courses. Dr. Sorcinelli has many years of experience in providing critical feedback and course revision suggestions to UMass faculty. The Center will also conduct more intensive formative evaluations such as video tape analysis in selected courses. *Dr. John Clement* will conduct intensive formative evaluation and research in selected courses. He has twenty years of experience in the analysis of student learning difficulties. His efforts will address generalizable learning issues which can inform other projects in the nation. *Co-PI Allan Feldman* will document the organizational development of STEMTEC.

- **Dissemination:** Co-PI *D'Avanzo* will lead in dissemination of results (Section 15). This will involve arranging for the preparation of videos, obtaining information about producing computer software, organizing STEMTEC research conferences, and coordinating publication and presentation efforts by STEMTEC participants.
- **Campus Coordinators:** Each campus will have a coordinator, in most cases an administrative staff member, who will ensure the smooth operation of STEMTEC enterprise on the campus. He or she will relay notices to the students, college faculty and teachers participating in the project affiliated with that college, assist in campus budgetary management, and facilitate the school experiences of the undergraduates on their campuses. Campus coordinators will meet monthly

with PI *Sternheim* and Co-PI's *Wilson* and *Feldman* to review overall STEMTEC progress and the teaching opportunities programs.

12. Faculty and Institutional Expertise

The Principal Investigator is Morton M. Sternheim, Professor of Physics. A nuclear physicist and textbook author, he has been actively involved in teacher professional development programs for over a decade. He is the Director of the STEM Education Institute (Appendix IV) and of the UMassK12 Internet Service project (Appendix IV). With Mary Alice Wilson, he has been the PI of two NSF-funded Five Colleges, Incorporated teacher enhancement projects. The Co-PI's provide a rich variety of experience and expertise in science teaching and teacher professional development. Richard Yuretich is Professor of Geosciences and Associate Department Head. He has been active in teacher development programs since 1990. Allan Feldman is Assistant Professor of Education; his field is science education with experience in pre- and in-service teacher education, and in program evaluation. He has had extensive experience as a middle and high school science teacher. Mary Alice Wilson is the Coordinator of the Five College/Public School Partnership and has built that organization into a major regional resource (Appendix I). Charlene D'Avanzo, Professor of Ecology, Hampshire College, is a leader in bringing modern pedagogy to college faculty, and also has produced an award winning video (Section 15.3). The evaluation team is exceptionally strong; see Section 11. Institutional demographics are tabulated in Appendix II.

13. Anticipated Results

We expect to see significant, measurable results in addressing each of our project goals. The summer workshops will train a total of 80 college faculty in the new pedagogical approaches, enabling them to create or modify approximately 74 courses. (Some faculty in the teams wlll serve as

resources and will not develop their own courses.) A larger group of college faculty will be affected by the seminars and workshops comprising the internal dissemination efforts.

After completion of the summative evaluation of the new courses, we will describe them and the evaluation results in publications, and in talks and workshops at national and regional meetings. One focus of our analysis and description of the courses is how changing the learning environment in science and math classrooms leads to students being more interested in learning and, consequently, in teaching science and math. Our program will result in the reform of approximately 74 courses in 5 disciplines and in 8 quite different colleges. The total annual enrollment in those courses will be in the thousands since large introductory courses will be modified. The number of science and math majors exposed to teaching experiences will also be large, 100 or more annually.

Findings about getting students interested in learning and teaching from this extraordinarily rich base will be transferable to a wide range of institutions. The evaluation will also help us understand which kinds of activities with schools and children draw college students into teaching careers. Educators will be interested to know whether any of these exposures is especially effective or if it is the variety of interactions with children that increases the population of college students interested in teaching. We are especially interested in the contributions made by the mentor teachers and the workshops for the participating students.

We expect to see a change in the cultures of the eight participating colleges. By changing science and mathematics courses and programs so that they are more welcoming to prospective teachers, they will be more welcoming to all undergraduates. The result would be that science and mathematics will be seen as worthwhile majors for all undergraduates. This will help us to reach "the second tier" (Tobias, 1990).

The project will have its greatest impact on the preservice education of elementary teachers and of secondary science and math teachers. The elementary teachers will have a sounder base in

these disciplines, and will be prepared to teach them using the pedagogical methods incorporated into the new courses. Science and math majors who become secondary teachers will have profited from experiencing the new pedagogies. The improved pedagogy and the recruiting efforts will produce significant increases in the number of women and minorities entering science and math teaching; CETP scholarships will allow 40 minority students to complete science and math teaching programs. The project will also improve the teaching of science and math in Western Massachusetts, since teachers who participate in the curriculum development committees and as mentors for undergraduates will increase their content and pedagogical knowledge. The use of educational technology in its many forms is a central part of STEMTEC. The infusion of educational technology into the new and revised courses as well as the educational technology courses will be adaptable to other campuses. Intelligent tutoring systems will be developed by STEMTEC and made available for national distribution.

14. Assessment and Evaluation

Assessment and evaluation will be carried out at multiple levels by a carefully assembled team of four senior staff, with the aid of two graduate students and a staff assistant (See Section 11). The plan is organized into two major sections: course reform efforts and teacher recruitment. The evaluation team will document the activities of the participants, inform the project managers of progress with respect to major milestones for the project, and implement the comprehensive formative and summative evaluation plan described below.

14.1 Course reform efforts

A major element of the course reform evaluation will determine the extent of changes in instruction and course materials of college science and mathematics courses. We intend to use course evaluation protocols and assess student changes based on student responses on these instruments. We

also intend to identify specific, successful courses and professors who, after participating in the workshops or curriculum committees, have significantly changed the way they teach. In these instances we will prepare more in depth case studies leading to publishable findings.

Formative evaluation will use the techniques of in-class observations, teacher evaluations, and student evaluations to provide ongoing feedback to project planners on how project goals are being met. Formative evaluation of course development will include data review sessions with the instructors. These will identify which parts of the course are working, which need modification, and to set out strategies for improvement.

Courses in which ambitious or disseminatable changes are being attempted will be targeted for additional formative evaluation. It will identify key interactions and any critical barriers to learning that are generalizable and will lead to informative publications. It will also give critical feedback on content and process learning objectives with specific reference to the five teaching strategies.

Summative evaluation will be implemented by an independent third party (the Donahue Institute). The impact of course reform on students will be measured through the use of questionnaires, focus groups of students, course evaluations, and key student performance indicators (such as final course grades, quiz and homework grades, and grades on standardized tests). Changes in student attitudes toward teaching will be measured using surveys and focus groups. Finally, interviews and videotaping of selected individual faculty will provide in-depth understanding of the difficulties and opportunities involved in the reform process.

14.2 Teacher recruitment

The evaluation team will document and evaluate the activities designed to increase the number of science, mathematics, and engineering majors choosing to become teachers, and to improve the induction of new science and mathematics teachers into the profession.

Formative evaluation will be accomplished through the use of observations, survey instruments, and focus groups to provide ongoing feedback to the PI's. Periodic reviews of progress with respect to identified milestones will inform management of any needed modifications to their efforts. A major function of the summative evaluation in the area of recruiting will be the documentation of the extent to which science and mathematics majors, especially women and minorities, choose to enter the teaching profession. Because of the symbiotic nature of this project, a second function of the summative evaluation is to determine the effect of the school/college interactions on both parties.

In addition to the evaluation and documentation activities described above, co-PI Feldman, an experienced program evaluator, will lead a team that will document the implementation and evolution of STEMTEC at the organizational level. Ethnographic and action research methods will be used to document the ways in which this multi-institutional reform project works. The information will be of particular importance to NSF in its attempts to replicate CTEP reform projects.

15. Dissemination

Dissemination will be both local and national; the former is essential to sustaining reform processes on the campuses. We will focus on program parts that are particularly noteworthy and transferable, and on the program as a whole. Of special interest to the college community will be:

- Our specific courses and curricula
- The process of helping faculty reform courses and curricula
- The impact of the program on future elementary, middle, and high school teachers
- Strategies for recruiting science and math students into teaching
- Strategies for recruiting under-represented groups

- Technology that enhances learning and is particularly useful for preservice teachers
- On the programmatic side, development and management of a consortium linking a flagship public university campus, private colleges, and community colleges to school districts with varied populations

15.1 Internal Dissemination

A strong program of internal dissemination will be critical to the process of changing the campus culture and creating a permanent process of educational reform. Curriculum team members will plan faculty seminars and workshops that can be given on their respective campuses. The STEMTEC Council will also sponsor larger campus-wide and multicampus programs to publicize the course changes, the student responses, and the underlying pedagogical principles. It will also work with the existing campus staff development programs to offer similar training workshops.

15.2 External Dissemination

The STEMTEC team members have strong track records publicizing educational materials and programs. We will employ journal publications, conference talks, world wide web pages, and workshops for school and college faculty. Two less common options discussed below are production of a video and hosting an international conference on reforming teacher education in science and math.

15.3 Video

We will produce a video for college science and math faculty who want to learn about a variety of active learning approaches featuring examples of good teaching for prospective teachers. It will take viewers into classrooms so that they can see new, innovative ways of teaching and its effect on students as learners and teachers.

We will select examples of active learning: students working together on problems in large classes, learning through investigation, and using creative educational technology. The classes will

differ in terms of subject, class size, and type of institution to bring home the crucial point that there is no "right way" to use these ideas and techniques. Despite these differences, the outcome for the courses is the same: students are actively engaged in learning science or math, they are excited about learning, and they talk and think about how they are learning. Teachers will discuss how they changed their teaching and why. Students will discuss their attitudes towards learning and teaching as a profession.

Co-PI D'Avanzo will organize this effort. She is the executive producer of the video "Learning Science and Math Together" which recently won a Silver Apple award from the National Educational Media Network and a certificate for creative excellence from the International Film and Video Festival. She will use the same production company, Spectrum Media, winner of numerous awards. Anker Publishers, which will distribute the video, sells to colleges and universities nationwide. Also, the Continental Cablevision Corporation will assist in dissemination of this video via its community channels. We anticipate that videos such as ours will be in demand as college reform efforts intensify.

15.4 International Conference

Colleges everywhere are confronting the same issues as STEMTEC. An international conference will feature representatives of CETP projects as well as other leaders in reforming science and mathematics education for future teachers in the United States and elsewhere. This will allow those who are already engaged at various stages to learn from each others' successes. It will be even more valuable to those individuals, institutions and consortia just beginning or contemplating reform efforts. Accordingly, the conference will be open to educators at all levels and widely publicized.

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Appendix I. The Five College/Public School Partnership

The Five College/Public School Partnership was organized in 1984 to strengthen the education of children in western Massachusetts by improving communication and sharing resources among the members of Five Colleges, Incorporated, the school systems of western Massachusetts, and local community, business and cultural organizations. It is founded on the belief that school and college faculty share common interests about teaching and learning: a love of subject matter, a commitment to helping students learn and make use of information, and an excitement about their own professional development. Because of these shared beliefs, faculty from all levels of education can benefit greatly from collaboration with one another and with other members of our community.

Through collaborative efforts, faculty share information and resources, work together to create engaging educational materials, and design new ways to address the needs and concerns of today's students. The Partnership is dedicated to exploring a variety of collaborative models that can both support and strengthen the professional development of school and college faculty as they work together with the entire community to improve their individual classroom practices and enhance the learning of all their students.

Partnership Programs:

- Summer institutes with academic year follow-up (all content areas, 100-200 teachers each year in 3-5 programs)
- Academic year seminar series (all content areas, 500-700 teachers and administrators each year in 10-15 series)

- Publications (print and on the web) including the quarterly newsletter—the Partnership Calendar—mailed to 6,000 school and 1,000 college faculty and administrators; a variety of directories including the Massachusetts Directory of Collaborative Eisenhower Projects; articles and materials prepared by project staff and participants. The 5C5E Handbook: Doing Science Research in the Classroom is available in draft form on the web at http://k12s.phast.umass.edu/~partner.
- Technical assistance and networking information to school, college, and policy-making groups on the development of collaborative projects.

APPENDIX II. Demographics

DISTRICT	# STUD	W	B	H	A	N	O	POVERTY
Amherst	3,681	50%	16%	16%	18%	-	-	25%
Franklin Cty	10,820	97%	1%	-	0.5%	0.2%	1.3%	22%
Hadley	644	98%	-	-	-	-	2%	2%
Holyoke	7,746	26%	3.9%	69%	0.6%	0.1%	-	71%
Northampton	3,082	80%	3%	13%	4%	-	-	24%
S. Hadley	2,334	95%	1%	2%	2%	-	-	2.8%
Springfield	23,535	29%	31%	38%	2%	-	-	75%
State		79%	8%	9%	3.7%	0.2%	-	

Table I. School district demographics: total student enrollments, percentage by ethnic background (White, Black, Hispanic, Asian, Native American, Other) and percentage below the poverty level as determined by the number of students receiving free or reduced price lunches. Percentages may not add to 100 due to rounding.

COLLEGE	# STUD	F	W	B	H	A	N	O
Amherst	1615	44.5%	70.2%	8.0%	9.4%	12.0%	0.4%	-
Greenfield CC	2294	65%	93.8%	1.2%	1.5%	2.6%	0.2%	0.7%
Hampshire	1031	55%	78.9%	4.9%	3.7%	3.0%	0.5%	-
Holyoke CC	3356	60%	74.1%	3.5%	12.2%	1.4%	-	8.8%
Mount Holyoke	1957	100%	80.3%	4.7%	4.3%	10.1%	0.6%	-
Smith	2500	100%	79.2%	3.8%	4.0%	12.1%	0.9%	-
UMass	18021	48%	82.3%	4.3%	3.8%	5.9%	0.3%	3.4%
Springfield TCC	6084	57%	61.5%	9.4%	9.7%	2.0%	0.6%	-

Table II. Undergraduate college demographics: total student enrollments, percentage female, and percentage by ethnic background (White, Black, Hispanic, Asian, Native American, Other).

APPENDIX III. The UMassK12 Internet Service

The UMassK12 team has pioneered in providing telecommunications services for Massachusetts K-12 teachers and students since 1986. It has offered full Internet access since 1993, first with a text-based system and more recently with a graphical interface option. Both systems feature access to a huge variety of educational resources with user-friendly interfaces and strong user support services. More than 8,000 teachers were introduced to the Internet by UMassK12, and it presently reaches over 2,000 Massachusetts classrooms. To visit UMassK12, telnet to k12.oit.umass.edu; login as guest. The web site is at http://k12s.phast.umass.edu.

UMassK12 is provided by the University of Massachusetts Amherst. With the assistance of other UMass campuses, the MassNet state college network, Westfield State College, Mount Holyoke College, and Franklin County Technical School, UMassK12 is available from many dialup access locations around the state. UMassK12 and its predecessors were begun with the aid of University of Massachusetts grants and were later supported by NSF teacher enhancement grants. It is presently supported by user fees plus donated networking services.

Appendix IV. The STEM Education Institute

The Science, Technology, Engineering, and Mathematics Education Institute (STEM Education Institute) at the University of Massachusetts Amherst is funded by the Provost and the Deans of Education and of Natural Science and Mathematics. Its Director is Morton M. Sternheim, Professor of Physics. STEM is designed to enhance the University's teaching, research, and academic outreach missions in its fields of interest. Its clientele includes K12 students, students in introductory college level courses, and school and college faculty working

with these students. Activities include coordination, encouragement and support of research, curriculum development, dissemination, and program implementation.

The Institute is an outgrowth of a Science After School Task Force established in March, 1992 to consider how to make it possible for Western Massachusetts teachers to take science, technology, engineering, and mathematics courses at the University. The task force included faculty and staff from the University and from area schools. It soon discovered that there were related issues waiting to be addressed, including preservice teacher education. It also learned that there are many members of the University and Five College community working in the area of K14 science, technology, engineering, and mathematics education. They are based in various departments and in many cases are not aware of other local programs related to their own interests.

The Institute brings these people together, facilitating joint efforts and avoiding unnecessary duplication. It brings coherence to programs that are presently totally disjointed. Above all, it play a major role in meeting the University's goals in academic outreach, teaching and learning, research, diversity, and multiculturalism. The synergistic effects of coordinating these efforts helps the University to play a leadership role in the national and state efforts to reform and improve science, technology, engineering, and mathematics education.

Activities include:

- Seminars for college and school faculty
- Facilitating courses for preservice and inservice teachers
- Sponsoring conferences, workshops, summer institutes
- Coordinating and assisting grant applications by participants
- Applying for grants from federal, state, and private sources

- Hosting lectures by distinguished visitors
- Providing a home for school and college sabbatical visitors
- Providing a clearing house for information about grants, programs and resources
- Producing publications.