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# STEMTEC II (followon grant) Proposal

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**STEMTEC II: The Science, Technology, Engineering, and Mathematics Teacher Education Collaborative Follow On Program**

The Science, Technology, Engineering, and Mathematics Teacher Education Collaborative (STEMTEC) is an NSF Collaborative for Excellence in Teacher Preparation (CETP) funded from August 1997 to July 2002. STEMTEC II is a request for a three-year follow on grant designed to produce a comprehensive summative evaluation and to implement an induction program for new teachers. It is being submitted by the Science, Technology, Engineering, and Mathematics (STEM) Education Institute at the University of Massachusetts Amherst (UMass).

The STEMTEC collaborative includes the Five Colleges consortium: UMass - the state's flagship campus - and four distinguished liberal arts colleges: Amherst, Hampshire, Mount Holyoke, and Smith Colleges. The collaborative also includes Greenfield, Holyoke, and Springfield Technical Community Colleges, whose graduates often transfer to the Five Colleges, and the neighboring school districts, which include inner cities, small towns, and rural areas. The Five Colleges prepare more Massachusetts secondary math and science teachers than any other campus or consortium in the state, reflecting the large numbers of talented majors in these fields.

## I. Description of original CETP project

STEMTEC, like all the CETPs, was committed to producing better prepared, more numerous, and more diverse science and math teachers. (Specific goals are listed below in section II.) Because the participating colleges have very strong undergraduate and graduate programs in science and mathematics, STEMTEC focused more on future secondary teachers than many other collaboratives, although attention was also paid to elementary teachers.

In developing the STEMTEC agenda, we noted that elementary teachers typically select their profession early in their college careers, so it is straightforward to recommend or require suitable courses. STEMTEC developed and recommended courses that provide the necessary content while modeling the kind of student-active learning that has been successful in science and math classrooms.

Potential secondary science and math teachers present a different challenge since they typically enter college with plans to attend professional or graduate schools. Few decide to teach until close to graduation or later. Accordingly, STEMTEC revised many mainstream courses for science and math majors to reflect the latest research in how students learn, so that these not-yet-identified future teachers had suitable courses. It also developed opportunities for students to have teaching experiences -- as tutors or teaching assistants on their own campuses, or with pre-college students -- encouraging students to think about teaching careers at an earlier time.

It is convenient to divide the programs conducted to achieve the project goals into two categories: *course improvement* and *the student program*. Course improvement required helped college faculty to adopt student-active teaching strategies and to create *STEMTEC courses* that feature inquiry-based pedagogy, collaborative group work (even in large classes), alternative assessment, teaching experiences, and educational technology. These and other issues were featured in a series of extended institutes and follow-up sessions. There were two summer institutes and a winter institute serving math, science, education, and engineering faculty in the core collaborative. Also, a new STEMTEC Faculty Fellows program targeted at junior faculty will meet alternate weeks for an academic year

starting in February 2002. Together, these programs will have served a total of 130 faculty members. There were also two summer institutes attended by 62 faculty members from 13 other Massachusetts colleges that prepare teachers. Fifty-eight K12 exemplary science and math teachers participated in these institutes as pedagogy experts and served on the curriculum teams that redesigned the college courses. The participating colleges all are supporting a variety of programs intended to provide professional development for their faculty. At UMass, for example, the Center for Teaching funds a Lilly Fellows program for new faculty and a Teachnology Fellows program for more experienced faculty. The community colleges have professional development days built into their union contracts; STEMTEC faculty members frequently serve as workshop leaders. The Five Colleges also offer a variety of workshops for their faculties.

The student program had several components, many of which are designed to last beyond the end of the NSF funding. These included

1. The scholarship program and associated support services: advising, and a program of events intended to support and encourage prospective teachers.
2. The Five College pre-education program. Science and math majors explore teaching careers, and future elementary teachers strengthen their math and science backgrounds. Requirements include STEMTEC courses, an education or psychology course, a seminar, teaching experiences, and a portfolio. At UMass, an Education minor is now under development which would serve a similar purpose.
3. New teacher preparation options. Amherst students can now prepare to be certified with courses taken at Mount Holyoke, Hampshire has added an educational studies option, and Mount Holyoke now offers additional secondary fields.
4. New science and math teaching transfer programs at the community colleges
5. Seminars on teaching and learning for math and science majors
6. Teaching experiences, either as part of courses or the seminars, or independent of these
7. A post-baccalaureate summer/fall secondary certification option that allows the required course work and student teaching to be completed between June and December.

STEMTEC has also pursued an ambitious dissemination program: papers in journals and at professional society meetings, and a series of annual *Pathways to Change* conferences on teaching and learning culminating in April 18-21, 2002 with an international conference Pathways 2002. This will be held in Arlington VA and is designed to allow CETP participants and others interested in science and math teaching and teacher preparation to share their ideas and programs. We have accepted approximately 90 papers by over 120 authors. An extensive web site (www.stemtec.org) includes annual reports and evaluation documents.

The current STEMTEC evaluation team is now in its second year. Its key findings for the year ending June 30, 2001, are that

1. STEMTEC has had a positive impact on reinvigorating science and math teaching on college campuses
2. STEMTEC has had a positive impact on the improvement of K-12 mathematics and science teacher preparation
3. STEMTEC has had limited success in fostering collaboration among its constituents

4. STEMTEC has fallen short of its goal to recruit underrepresented minorities into the math and science teaching profession

The full evaluation report is available at www.stemtec.org/about/project/eval/eval.html. The executive summary appears in Appendix A of this proposal. Appendix B discusses the program capabilities of the evaluation team.

Definitions: For the purposes of this proposal, a *STEMTEC-Educated Teacher* is a math or science teacher who has completed a teacher education program at UMass, Smith, or Mount Holyoke colleges. Students from any of the STEMTEC colleges can enroll in the UMass or Smith programs, and the Mt. Holyoke program is also open to Amherst and Hampshire students. In addition, STEMTEC-Educated Teachers have been students in *STEMTEC courses*. We define a STEMTEC course as being student-active, featuring inquiry-based pedagogy, collaborative group work, alternative assessment, teaching experiences, and educational technology. This includes courses developed under STEMTEC as well as other courses that have been demonstrated to meet these requirements.

## II. Evaluation Plan

Like many other CETP projects and other large programs, STEMTEC has found evaluation to be a challenge. During the first three years, two different evaluation teams tried with minimal success to develop an adequate plan for evaluating the many components. The present team led by Associate Professor Steven Sireci and Assistant Professor Joseph Berger of the UMass Center for Educational Assessment began its work in the summer of 2000 and has been very effective in developing and executing a comprehensive evaluation program. They submitted an excellent report of their first year's work in October 2001 (See Appendix.) Their evaluation of STEMTEC in years 4 and 5 provides a solid foundation for the summative evaluation.

In considering prior evaluation work, and the comments of the National Visiting Committee, the current evaluation team has spent the last year-and-a-half academic focusing on determining whether the STEMTEC Collaborative has:

(a) reinvigorated the teaching of math and science,
(b) increased the number of students who enter the math and science teaching professions,
(c) increased the number of underrepresented minorities who enter the math and science teaching professions, and
(d) supported K-12 science and math teachers.

These priorities were developed as part of a broader review of the following goals of the STEMTEC initiative:

1. Establish a functional educational collaborative.
2. Redesign the science and math curricula on the campuses of the Collaborative to incorporate new pedagogies and establish mechanisms for supporting faculty in their course redesign.
3. Improve preparation of future K-12 teachers of mathematics and science.
4. Recruit and retain promising students into the teaching profession, with special attention to underrepresented groups.

5. Develop a program to support new science and math teachers in their first year in the classroom.
6. Establish dissemination mechanisms.
7. Conduct strong programs of evaluation and assessment.

The majority of existing efforts have focused on evaluating the impact of STEMTEC on faculty, courses and students on the campuses of the eight postsecondary institutions participating in STEMTEC. Evaluation of how STEMTEC, through the preparation and support of new teachers, is impacting science and math education in K-12 settings has only begun to be systematically evaluated during the fifth year of the initiative. Supplemental funding for an additional three years of funding for evaluation would be used primarily to continue existing assessment activities, but with a particularly strong emphasis on examining the outcomes of STEMTEC efforts in K-12 schools.

The evaluators would build upon existing evaluation activities and would work closely with the CETP evaluation core at the University of Minnesota to contribute to the larger national CETP database. The STEMTEC goals listed above would be prioritized for evaluation in the following manner:

| | |
|---|---|
| *Priority One*: | Improve the preparation of future K-12 teachers of mathematics and science (Goal 3). |
| *Priority Two*: | Recruit and retain promising students into the math and science teaching profession, with special attention to underrepresented groups (Goal 4). |
| *Priority Three*: | Develop program to support new science and math teachers in their first year in the classroom (Goal 5). |
| *Priority Four*: | Establish dissemination mechanisms (Goal 6). |
| *Priority Five*: | Redesign the science and math curricula on the campuses of the Collaborative to incorporate new pedagogies and establish mechanisms for supporting faculty in their course redesign (Goal 2). |
| *Priority Six*: | Establish a functional educational collaborative (Goal 1). |
| *Priority Seven*: | Conduct strong programs of evaluation and assessment (Goal 7). |

The first three priorities would receive the greatest amount of emphasis in subsequent evaluation efforts. Priority four would focus on dissemination to practitioners in the field, particularly those who work in local school districts in which a number of graduates from the STEMTEC programs have been employed as teachers. While less attention will be given to priorities 5-7, we will continue to assess the long-term effects in these areas that continue past the initial five-year funding period.

In order to conduct these assessments, we would build on the core evaluation plan that has been constructed by the CETP core evaluation team at the University of Minnesota. As such, we would be incorporating the core evaluation team goals and instruments into our research design. However, we will also conduct some additional surveys and observations of our own above and beyond the minimum core expectations. Much of the additional survey work will focus on new teachers, particularly those who are employed outside of the local school districts in close proximity to the

Table of K-12 School sample[1]

| | K-12 principals | K-12 teachers | | | Scholars | K12 students |
|---|---|---|---|---|---|---|
| | | STEMTEC Local | STEMTEC Non-Local | Non STEMTEC | | |
| Mail Surveys | XX | XX | XX | XX | XX | XX |
| Observations (evaluative rating) | | XX | | XX | XX | |
| Artifacts | | XX | | XX | XX | |
| New Teacher Support Programs Observations, Interviews & Surveys | | XX | | | | |

## Table of Institutions of Higher Education (2 year and 4 year) Sample[2]

| Institution Survey | 2 year | | | | 4 year | | | | Scholars |
|---|---|---|---|---|---|---|---|---|---|
| | Faculty | | Administr. | | Faculty | | Administr. | | |
| | SMET | Educ | SMET | Educ | SMET | Educ | SMET | Educ | |
| Dean/Department chair | | | XX | XX | | | XX | XX | |
| Scholar Survey | | | | | | | | | XX |
| Faculty Survey | XX | XX | | | XX | XX | | | |
| **For those STEMTEC faculty who indicated in survey that they made changes to their courses** | | | | | | | | | |
| Surveys | XX | XX | | | XX | XX | | | |

| Courses, up to 15 | | | | |
|---|---|---|---|---|
| **Data to collect** | **2 year** | | **4 year** | |
| | SMET Faculty | ED Faculty | SMET Faculty | ED Faculty |
| Observations | Observations distributed among SMET and ED courses and types of institutions so as to be representative of STEMTEC. | | | |
| Artifacts (a lesson & an assessment) | | | | |
| Student Surveys | Surveys will be distributed to students in all observed classes | | | |

[1] Adapted from CETP Core Evaluation Planning Documents
[2] Adapted from CETP Core Evaluation Planning Documents

STEMTEC home base. We also plan on obtaining larger samples for some of the surveys, particularly in K-12 settings and we will conduct additional classroom observations at the K-12 and higher education levels. We will also conduct numerous observations, surveys, and interviews that specifically target the on-going new teacher induction and support efforts of STEMTEC. The matrices on the preceding page have been adapted from core materials and summarize our data collection efforts.

Building upon the basic evaluation goals of the CETP core evaluators, we will more specifically address the assessment of STEMTEC priorities through the activities described below over the next three years.

*Priority One*: Evaluating Goal 3, "Improve the preparation of future K-12 teachers of mathematics and science."

Goal 3 focuses on how well STEMTEC has improved the preparation of K-12 math and science teachers. Our evaluation of Goal 3 will involve interviews and surveys of K-12 teachers who received STEMTEC training. In addition, the evaluation will attempt to include an comparable cohort of K-12 teachers who did not receive STEMTEC training. Further, we will interview elementary and secondary administrators to determine if they perceive a difference between their teachers who received STEMTEC training and those who do not. The teacher surveys and interviews will focus on specific teaching and assessment practices used by the teachers, as well as their adherence to national standards in math and science (e.g., NCTM, NSTA). Also, we will survey or interview K-12 teachers who are serving as mentors to the student teachers from the STEMTEC program. We will inquire about the strengths and weaknesses of the program as well as any perceived differences in STEMTEC versus non-STEMTEC students, if possible. We will also conduct a number of classroom observations over time to assess the extent to which K-12 teachers who have participated in STEMTEC courses and programs as undergraduates are incorporating reformed teaching practices into their classrooms.

Although we will continue to need to develop and use our instruments, CETP core survey instruments and classroom observation protocols will be used wherever possible. We will also utilize CETP core recommendations regarding sampling for surveys and classroom observations each year of the project; as such we will identify a local impact area for K-12 schools and identify 60 second or third year teachers (30 STEMTEC and 30 non-STEMTEC) as targets for the teacher survey. We will also survey principals in those schools. Additionally, we would conduct 6-12 classroom observations of STEMTEC and non-STEMTEC teachers and collect instructional artifacts from observed teachers. We will also observe 5 teaching scholars and survey all scholars (whether engaged in the teaching profession or not).

*Priority Two*: Evaluating Goal 4, "Recruit and retain promising students into the math and science teaching profession, with special attention to underrepresented groups."

Goal 4 will be assessed by evaluating the numbers of students who enter science and math teaching as a profession and by examining the extent to which students in STEMTEC courses express greater interests in science and math and teaching careers. The retention of STEMTEC graduates as teachers will also be assessed by tracking these students longitudinally and comparing their retention rates with non-STEMTEC graduates. Additional analysis will be conducted on employment trends and

career paths of the participants in the scholars program. We will continue to work closely with the registrars and alumni offices of the eight participating institutions to track these students.

Goal 4 will also be evaluated by tracking the number of STEMTEC participants of various underrepresented groups. We will compare these numbers to campus demographics and perhaps with data from other CETP sites. The evaluation will also document the specific efforts and events targeted at recruiting members of underrepresented groups. Focus groups may be necessary to determine the effect that STEMTEC has directly had on various groups.

*Priority Three:* Evaluating Goal 5, "Develop program to support new science and math teachers in their first year in the classroom."

Evaluation of Goal 5 will focus on documenting participation rates in each of the STEMTEC sponsored programs and events designed to support new teachers. New teachers will be included in survey and interview (individual and focus group interviews) research as a means of assessing how they perceive the support they are receiving from STEMTEC related activities. Administrators will also be surveyed about how well STEMTEC support efforts are meeting the needs of new teachers. Additionally, evaluators will observe various support activities. Specific questions will inquire about the strengths and weaknesses of the support these teachers receive from STEMTEC. We will pay particular attention in our evaluation of this goal to new activities, including the web-based components, that are sponsored as part of the supplemental funding.

*Priority Four*: Evaluating Goal 6, "Establish dissemination mechanisms."

Goal 6 refers to the degree to which STEMTEC effectively communicates its success and lessons learned at the local, regional, national, and international levels. Previous and planned dissemination activities will continue to be documented and evaluated, with particular attention given to the dissemination of information to local school districts and new science and math teachers in those districts. In addition to using the CETP core surveys, we may conduct some survey efforts of our own with local teachers and K-12 administrators to assess how well the dissemination of STEMTEC knowledge has been shared with local educators.

*Priority Five*: Evaluating Goal 2, "Redesign the science and math curricula on the campuses of the Collaborative to incorporate new pedagogies and establish mechanisms for supporting faculty in their course redesign."

Goal 2 has been a strong focus of the evaluation in each year of the project, but will receive less attention in the supplemental evaluation activities which will focus more on the external impact of STEMTEC on K-12 science and math education. Periodic review of how well STEMTEC has maintained transformation of postsecondary teaching will be conducted through surveys and observations. We will conduct interviews and surveys, incorporating the CETP core instruments into these efforts, as means for evaluating how well the original collaborative was able to develop and sustain reformed teaching cultures and associated formal support structures at participating departments and campuses. In order to accomplish this specific evaluation goal, we will survey all deans and department chairs and three faculty members from each science and math department at the eight participating institutions. We will also survey all STEMTEC faculty who have formally changed their courses and all survey all scholars during their senior year in order to get a student

perspective. Finally, we will observe 12-15 classes to see how well reform teaching is being sustained after the initial funding and we will survey students in other courses about the extent to which reform teaching is continuing to be incorporated in classes.

*Priority Six*: Evaluating Goal 1, "Establish a functional educational collaborative."

At this stage in the project, evaluation of Goal 1 will obviously not involve formative feedback. For all intents and purposes, a functional collaborative has successfully been established. Also, an assessment of the strengths and weaknesses of the way the Collaborative currently functions will be reported. This priority will be assessed using the administrator surveys and by conducting interviews of faculty and administrators.

*Priority Seven*: Evaluating Goal 7, "Conduct strong programs of evaluation and assessment."

This evaluation plan is designed to address Goal 7. The plan outlined here, and the activities associated with it, constitute a comprehensive plan for assessing the strengths, weaknesses, successes, and failures of STEMTEC.

## III. New Teacher Induction and Support

The STEM ED Institute seeks to extend the STEMTEC student program into the first several years of teaching. We propose a multiple model approach to best serve two groups of new teachers. The first consists of STEMTEC-Educated Teachers, as defined in Section I; they have completed teacher education programs within the collaborative. Most of the STEMTEC-Educated Teachers are teaching in Massachusetts, but many are beyond the commuting radius of the campuses. A smaller number are spread across the country. In addition to the STEMTEC-Educated Teachers, there is a second group of new teachers that STEMTEC II will serve. They are the new math and science teachers in the three county area spanned by the collaborative. Clearly there is some overlap between the two groups.

From the beginning of the project, STEMTEC has searched for ways to support new science and math teachers in our area. All the new teachers receive personal invitations to participate in our program. A variety of approaches have been tried with uneven results.. Our proposed program reflects three important points:

1. Efforts must be targeted to the immediate needs of the new teachers
2. New teacher support efforts must be coordinated with district-based efforts.
3. In addition, policy makers at the state (MADOE certification regulations) and national levels (NCATE) have begun to mandate that college and university teacher education programs continue to serve their students through the induction years.

During the past two years we have acted on the first point by developing a teacher collaborative group model, which we describe below.

In our development of this proposal we acted upon the second point by seeking a close collaboration with the induction program of the local school districts that are part of the STEMTEC collaborative. We consulted with professional development supervisors in three representative schools: Erlene

Provost and Linda Abbott (Springfield Public Schools), Carol Jacobs (Greenfield Public Schools), and Wendy Kohler (Amherst Regional). The three districts are quite different in many respects: Springfield is the third largest city in the state, with most of its students drawn from minority groups; Greenfield is an old factory town that serves as the seat of a poor rural county; and Amherst is the college town which hosts Amherst and Hampshire Colleges and UMass. Nevertheless, they presented much the same prospective on the needs of their new teachers (*see letters.*)

All three districts provide mentors for new teachers, in accordance with Massachusetts Department of Education requirements. These mentors receive some training, and they work one-on-one with the teachers on general issues such as classroom management, communicating with parents, etc. The districts believe that this arrangement works reasonably well. In addition, experienced teachers who serve as peer coaches provide support on subject-specific issues, but this seems to be less satisfactory. All three districts expressed strong interest in having content-based workshops that the new teachers and the coaches could attend together. It was stressed that such workshops should be aligned with the Massachusetts Curriculum Frameworks and should consider assessment issues. It was also stated that funds were available to pay for teachers to participate in workshops and possibly also for courses.

The third point has led us to work with the UMass Secondary Teacher Education Program (STEP) as they redesign their teacher education program in response to new NCATE and MADOE regulations.

The new teacher induction and support has three main components: the teacher collaborative group; STEM Ed Institute programs including Science and Engineering Saturday Seminars; and a re-designed UMass Teacher Education Program, which includes an online seminar, plus an "appropriate" master's program with a strong content research component for the teachers. These will now be explored in detail.

A. Teacher Collaborative Group

Following on the research of Uri Triesman (1992) science and math educators have recognized the importance of collaboration as a way to enhance learning. More recently evidence has accumulated that the enhanced learning is related to the type of discourse that occurs in the groups (e.g., van Zee et al., 2001; Crawford et al., 1999). Similarly it has been demonstrated that teachers can learn to be better teachers by becoming a part of a collaborative learning community (Hollingsworth, 1994; Feldman, 1999; Clark, 2001).

In the fall 2000 term, we initiated a teacher collaborative learning group similar to the models used by Hollingsworth and Feldman. A group of 6-10 teachers meet approximately once every three weeks for dinner at the Five Colleges offices. Two other teachers, who have taught 2-5 years, act as facilitators; one of these is a former STEMTEC Scholar. The meetings begin with general conversation about teaching and then focus on an announced topic such as assessment or the statewide student tests. Participants often arrive discouraged over their difficulties, and after engaging in collaborative conversations (Hollingsworth, 19XX) about their work, leave with new ideas and insight into their teaching situations. The new teachers are also kept informed about various workshops and other professional development opportunities. The STEMTEC evaluators are currently engaged in an in-depth study of the efficacy of the group.

We plan to continue this program in STEMTEC II to serve STEMTEC-Educated Teachers and other new teachers in the local area. We will add an online component that will help participants to keep in touch between meetings, and will also allow some level of participation for teachers who cannot attend the sessions. Since the districts have funds allocated to professional development, we anticipate their support to sustain the program after the end of the grant. Costs for this program are minimal: a small stipend for the facilitators plus the cost of dinners. In STEMTEC II we will also provide the teachers with Internet access through UMass K12, our pioneering Internet service with a fifteen-year history of service to Massachusetts schools.

B. STEM Ed Institute Programs

As noted above, the school districts want opportunities for its new teachers and their peer coaches to attend content workshops connected to assessment and frameworks. One response will be provided by adapting and extending a year-old program of Science and Engineering Saturday Seminars sponsored by the STEM Education Institute and the Raytheon Corporation. (Raytheon will provide $10,000 per year for two years to support these seminars in STEMTECII.) The Institute will also offer additional programs including twice-monthly afternoon seminars and summer workshops. (See www.umassk12.edu/stem for current and recent programs.)

There are six Saturday Seminars per term; they meet from 8:30 to 1. Each of the first four is devoted to a single topic: *Fast Plants, the Physics of Music, Building Big, Air Quality, A Walk Through the Jurassic*, etc. Two are presented by STEMTEC science faculty, and two by STEMTEC or Raytheon engineers. The inclusion of the engineering seminars is particularly valuable because the Massachusetts curriculum frameworks now include engineering and technology, and teachers need help in understanding how to implement this requirement. The fifth is devoted to assessment issues and to the curriculum frameworks, and the last is devoted to discussing lesson plans that have been developed by the participants. PI Sternheim organizes the program; he is assisted by Chris Emery, a physics and electronics teacher at Amherst Regional High School with 15 years of professional development experience, who leads discussions of frameworks and related issues. Co-PI Feldman conducts the assessment session.

The individual seminars vary considerably in format. Some include using the web or computer simulations; one was a geology field trip. All include hands-on lab activities and materials that can be adapted to classroom uses. Teachers completing the six seminars, readings, and a lesson plan may receive graduate credit at a nominal charge; professional development points (PDP's) required for recertification are also available at no cost.

Each term about 50 teachers take part in one or more seminars; attendance is capped at 30, and every session is full. Some participants have been teaching many years, while others are in their first or second years. Evaluation of program overall, including its format and content, has been very positive. In the fall 2001 semester, every participant filling out the evaluation form rated the program as good or excellent and all were likely to use the materials in their classrooms. Many of the teachers created very ambitious projects based on the materials, including a science overnight for 300 seventh and eight graders, and an engineering expo for 48 eighth graders. The geology field trip and the air quality workshop enriched a unit on evolution and ecology. A middle school built a school-wide

project for 657 students around a chemical engineering activity, the creation of lip balm, exploring the entire engineering process including feasibility, process, controls, etc.

As part of the STEMTEC II program we will survey new teachers to determine the topics of special interest to them, and will give priority to the new teacher – peer coach pairs in registering for these seminars. The costs include honoraria for the seminar presenters, educational materials, refreshments, and a stipend for Chris Emery. The UMass system has a large grant from Raytheon to improve engineering education that includes modest funds for k12 outreach administered by the College of Engineering. This grant will support the seminars for the first two years of STEMTEC II. Modest fees will support the seminars in year 3 and in later years. We see this component of our new teacher support meeting the induction needs expressed by the Districts.

The STEM Education Institute also offers twice monthly afternoon seminars on a range of topics. These are open to everyone in the educational community, and bring together a diverse K12 and higher education group including new teachers. Recent topics included *Using a Mock Trial to Develop Scientific Literacy in Introductory Geology*, *Engineering – A Marvelous Integrator for All Learners (K-16), Using Technology To Facilitate The Use Of Formative Assessment In Physics,* and *Reducing the Distance in Distance Learning.*

Finally, the Institute seeks funding from various sources for other teacher workshops and courses. For example, it has offered *Planet Earth* summer institutes and academic year follow-up meetings on earth systems science to a mix of inservice and preservice teachers with funding from NASA initially and the Massachusetts Space Grant Consortium subsequently. It has also used Eisenhower funding to offer course in physics and in nutrition. New teachers have a high priority in such programs.

C. Re-Designed UMass Teacher Education Program

Recent changes in the Massachusetts teacher licensure regulations and in NCATE standards have led to a re-examination of the UMass Secondary Teacher Education Program (STEP). STEP has been the home for several innovative teacher education programs, such as the nationally recognized "180 Days in Springfield" option and the STEMTEC funded and initiated Summer/Fall Option. In addition, it is one of the largest producers of new math and science teachers in the Commonwealth and serves as a yardstick against which other programs are measured. Two new components of STEP will be developed as part of STEMTEC II. The first is a netcourse seminar for new math and science teachers, which will be accessible to STEMTEC-Educated Teachers anytime, anywhere. The second is an “Appropriate” Masters Degree. This redesigned degree program will also provide a vehicle for research.

Netcourse: Being a New Math and Science Teacher

The netcourse *Being a New Math and Science Teacher* will be the primary vehicle for interacting with STEMTEC-Educated Teachers who have left the local area. This course will be an extension of a course that Co-PI Feldman piloted in the Fall 2001 semester (http://www-unix.oit.umass.edu/~afeldman/new.html). The course covers a variety of topics important to this group:

- Classroom management
- Formative and summative assessment

- Web-based instruction
- Inclusive pedagogy
- Writing in science
- Student research
- Teacher research

This course will be required for new teachers enrolled in the redesigned Master's program. It is based on readings and discussions about the topics in the course and draws heavily on the experiences of the participants. It was very successful in helping the new teachers to reflect on their teaching and to learn new teaching strategies.

As a conventional real time seminar this course was limited to those able to come to the UMass campus in Amherst at a set time each week. As a netcourse it will be available to all STEMTEC-Educated Teachers, wherever they teach. PI Morton Sternheim has had several years of experience with netcourses (Cohen 1998, 1999; Sternheim 1996), and will assist in creating the online version. Professor Nancy Cohen (Head, Nutrition Department), who has developed netcourses for teachers and undergraduates as well as *Cyberseminars* for nutrition professionals, will serve as a consultant in designing the course.

The focus of the course will be small group discussions based on web and print readings using the WebBoard software used in earlier courses. We have found that this environment is very effective in getting all the participants actively engaged in the discussions, and leads to a high level of student-student and student-professor interactions. The course home page will contain links to a variety of educational resources. Assignments will include locating, evaluating, and adapting Internet based teaching materials. Occasional on campus meetings will supplement the online activities for those able to attend.

Since this course will be part of Feldman's teaching assignment, it will not be dependent on grant funding beyond the development stage.

The "Appropriate" Masters Degree

The second new component of STEP is a new masters degree to satisfy the Commonwealth's requirements for the new *Professional Licensure*. For secondary school teachers (middle and high school), the professional licensure requires the completion of an "appropriate" masters degree. Simply put, this means that at least half of the credits for the degree must be in the academic discipline that corresponds to the area of licensure. For math and science teachers we propose that a significant portion of the subject matter credits be from participation in research projects supervised by STEMTEC faculty. During the spring semester the teachers will be enrolled in an introduction to research in the discipline course in which they meet regularly with STEMTEC faculty to become integrated into their research projects. The teachers will be full-time researchers during the summer. They will continue with research during the fall semester while enrolled for 3 credit hours of independent study. They will then be required to have their students engage in scientific research in the manner described in *Science Experiments and Projects for Students* (Cothron, 2000) and to complete an action research study of their teaching of scientific inquiry methods (Feldman & Minstrell, 2000). STEMTEC faculty involved in this component will be encouraged to submit seek Research Experience for Teachers (RET) supplements to their current NSF awards. RET supplements

are currently available form the Engineering Directorate and the Directorate of Mathematical and Physical Sciences.

The model described above provides an opportunity for teachers to engage in a full cycle of scientific research with a faculty member in math or science, and to use that knowledge in their work with middle and high school students. We feel that this will be an important step towards helping teachers to meet the “Science as Inquiry” standard of the National Science Education Standards (NRC, 1996), which states that students should understand the nature of science as inquiry and “requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science.” In addition, the Content Standards call for students to know and understand the history and nature of science as a way to “clarify different aspects of scientific inquiry, the human aspects of science, and the role that science has played in the development of various cultures.” Clearly if teachers have the opportunity to engage in authentic scientific or mathematical research, they will be more qualified to help their students to understand the nature of inquiry in the disciplines.

Research on the "Appropriate" Masters Degree

The "appropriate master's degree model described above provides an excellent opportunity to study the effects of teachers' participation in research on their practice and their students' learning. We suggest two hypotheses that can be tested:

1. Do middle and high school math and science teachers engaged in research studies gain knowledge and understanding of scientific and mathematical processes and methods that are in-line with those of experts? If so, how can we account for the learning that occurs?

2. If middle and high school math and science teachers do gain new knowledge and understanding of scientific and engineering processes and methods, how does that affect their teaching? Do they provide their students with opportunities to learn about the nature of science and engineering and about scientific methods? Do their students gain knowledge and understanding of scientific and mathematical processes and methods that are in-line with those of experts?

We will use three primary methods to answer these questions. First, participants will complete pre- and post- surveys using one of the standard instruments developed to uncover beliefs about the nature of science (e.g. Nature of Science Survey (Lederman & O'Malley, 1990) or the Views on Science-Technology-Society (VOSTS) survey (Aikenhead & Ryan, 1992)). Second, all team members will be interviewed at the beginning of their participation in the project and at the end. In addition, teachers will be interviewed six months after the end of their participation. The interview protocol will include innovative techniques such as the card sort (Feldman & Kropf, 1999) and critical incidents (Nott & Wellington, 1998). The third method will be observations of the teachers' classes. The observation instrument will be based on the one developed for the CORE evaluation of the NSF-funded Collaboratives for Excellence in Teacher Preparation.

Survey questions will be analyzed using standard descriptive and inferential statistical procedures. Interview and observation data will be analyzed using the coding of qualitative data as described by Miles and Huberman (1994); domain, taxonomic, and componential analysis to determine critical patterns and themes (Spradley, 1979; 1980); and through the construction of understanding inherent

in the use of long and serious conversations as research (Feldman, 1999). Both pre-conceived and emergent categories and themes will be used for coding of qualitative data. The pre-conceived categories will be derived from the research literature on the nature of science while emergent categories will be derived inductively from the data, following the methods of the development of grounded theory (Strauss & Corbin, 1990).

## IV. Project Management and Personnel

The Principal Investigator for STEMTEC II will be Morton M. Sternheim, Professor of Physics Emeritus, and Director of the STEM Education Institute. He was the lead PI for the original STEMTEC project, and has 16 years of experience in educational outreach and teacher professional development. He has received several awards, including the UMass Chancellor's Medal for his outreach efforts, and the American Association of Physics Teacher Janet Guernsey award for excellence in physics teaching. He will be responsible for overall project management, and for planning and managing the Science and Engineering Saturday Seminars and the twice-monthly STEM seminars. He will also be responsible for the technology aspects of the project, including the STEMTEC web site and online discussions for the Teacher Collaborative Group. His experience with netcourses will be invaluable in developing the new netcourse, *Being a New Math and Science Teacher*.

Allan Feldman, Associate Professor of Science Education, will be the co-PI; he was one of the PI's in STEMTEC. He will take general responsibility for the new teacher support program, and will teach the netcourse, *Being a New Math and Science Teacher.* He will also undertake the proposed research on the *Appropriate Masters Degree.*

Chris Emery, a physics and electronics teacher at Amherst Regional High School with 15 years of professional development experience, will assist with the Saturday Seminars and leads discussions of frameworks and related issues. (He will be funded for the first two years by Raytheon, and the last year by fees.) Two other teachers will moderate the meetings of the Teacher Collaborative Group.

Nancy Cohen, Professor of Nutrition, who has developed netcourses for teachers and undergraduates as well as *Cyberseminars* for nutrition professionals, will serve as a consultant in designing the course.

The evaluation team will be led by Associate Professor Steven Sireci and Assistant Professor Joseph Berger of the UMass Center for Educational Assessment, as has been the case since the summer of 2000. A Project Manager and a graduate student will assist them. The budget also includes funds for other evaluation experts to provide expertise in specific components of the evaluation, which may include the web-based component of the new teacher support efforts and an expert in focus-group research to work with participating new faculty.

The University will provide a half time secretary to manage the logistics and paperwork associated with both the evaluation and new teacher support programs. A second graduate student and an

undergraduate assistant will be funded under this proposal to provide additional program support and to assist Feldman with his research.

Additional details will be found in the Budget Narrative.