The principal activities of the MASTEP Project have been: A. Establishing the Collaboration between the Various Institutions, B. Establishment of Future Teacher Clubs, C. Recruitment of Future Teachers, D. Offering New Teacher Support Networks, E. Offering Teaching and Learning Conferences for Faculty, and F. Course Revisions at the College and University Levels.

Below we present our findings about each of these activities, plus we include some of the conclusions reached by our outside evaluators, WestEd from San Francisco, and by our National Visiting Committee (a distinguished panel that evaluated our efforts annually).

A. Establishing the Collaboration between the Various Institutions:

We consider our most important collaboration to be the close cooperation that we created among the faculty of our six institutions of higher learning. Prior to MASTEP, few faculty knew anyone on the other campuses, and fewer still had ever worked together on curricular projects. Community College faculty at our four campuses reported that they had always felt left out of important decisions about degree requirements and articulation with the universities. It was as though the university faculty made the decisions and then told the Community College faculty what they must do to comply.

To create a system of equal governance and participation in MASTEP and its activities, we formed two important committees: The Executive Advisory Board to oversee all MASTEP activities, and the Teaching and Learning Committee to design our faculty workshop series and to fund course proposals from the six institutions. Each of the six campuses provided a representative for these committees, plus we added a few other members that directed important components of MASTEP (such as the New Teacher Support Networks and K-12 connections). This structure immediately impressed upon everyone that all members were equal players in our Collaborative.

Faculty across the campuses became acquainted at our faculty workshops where we intentionally created sessions requiring faculty to work together on curriculum development activities. Also, we placed emphasis early on funding course development projects that involved as many of the six campuses as possible. The objective was to get

faculty to design and implement courses for future teachers that were the same at both the Community Colleges and the Universities. The outcome was as expected, faculty became close colleagues and even friends as a result of working together, and they learned new approaches to teaching and learning together. As our WestEd Evaluators concluded after three years into the project, "We know that faculty are energized and are collaborating with each other across institutions in new and different ways." And, "Faculty perceived a decreased sense of isolation following contact with like-minded colleagues." In the end of Year Five Evaluation Report, WestEd specifically addressed our project goal of: "To establish on ongoing collaboration among San Jose State University, San Francisco State University, Evergreen Valley College, City College of San Francisco, San Jose City College, and the College of San Mateo for the reform of science and mathematics teacher preparation." Their conclusion was, "It is our opinion that the work of MASTEP has seeded new relationships that will continue after the original project funding ceases. Based on the evidence we have collected, we feel confident in saying that the project has met this goal."

A second important collaboration was with selected K-12 (mostly middle and high school) teachers who participated in our project. We needed the enthusiastic assistance of local teachers for two crucial activities: supervising our students in their "student teaching" experience and accepting our undergraduates preparing to go into teaching into their classrooms as early field experiences. Of course, such teachers must be outstanding model teachers since they would be influencing the thinking of future teachers. We wanted school sites with strongly student-centered approaches to instruction and where the science and math curricula were dynamic and forward looking.

To help create such dynamic sites, we recruited teams of science and math teachers interested in coming to our faculty workshops, including coming to extended summer programs in multimedia, meteorology, and water quality studies. When the teachers completed these workshops and programs, we provided them with equipment for their classrooms so that they could teach their students more effectively. Most of the teams also began student Clubs for science and math activities so that interested students could do science and math fair projects. We invited many of these teachers to be part of course development teams with the college and university faculty. These participating K-12

faculty became energized about educational reform in the same way as did our college and university faculty. A particularly motivating feature for these K-12 teachers was our placing multimedia equipment and an electronic weather station in each of their schools. These stations were networked to both our MASTEP website and to TV Channel 11 in San Jose, where Chief Meteorologist John Farley reported the weather conditions daily using our school sites. John also provided tours of the TV station for the teachers' students, and he was the primary instructor in the summer meteorology programs. The K-12 teachers and their students were especially jazzed about the TV exposure. Of course, the MASTEP Project benefited because our future teachers and "student teachers" got to work in these schools and be part of the excitement.

Because the MASTEP logo and website were featured on the weather reports by TV Channel 11, the project got tremendous exposure to the public. People that we would meet for the first time remarked that they knew of MASTEP. And, almost all of the students who enrolled in our science and math credential programs over recent years first contacted our MASTEP Office as the point of entry into our teacher preparation programs. This wide exposure doubtless was also pivotal in our obtaining liberal funding from local industries to augment our activities. Over the first few years of MASTEP, we obtained about $1.7 M in cash or product donations to assist our efforts.

Besides the above relationships with industries, we also formed collaborations with informal educational institutions and government labs throughout the SF Bay Area. These institutions helped us in several ways. They often referred to us people with an interest in a teaching career. They also provided internships and other positions so that some of our future teachers could gain valuable experience in other settings. The AMP (Alliance for Minority Participation) and MESA (Mathematics, Engineering, Science Achievement) Chapters at our two universities also partnered with us by sending to us their students who were interested in teaching.

Each of the above examples of collaborations that we formed proved to be very successful, and they live on because MASTEP still lives on.

B. Establishment of Future Teacher Clubs:

As described in the above "activities" section, initially each of the six MASTEP campuses formed a Future Teacher Club. Subsequently, San Jose City College

deactivated its Club because it felt that the several courses that target future teachers were serving to network the future teacher audience and allowed the faculty to communicate important advising and career opportunities. In general, the Clubs have provided a needed career outlet for future teachers where none was available previously. In the first year of the Club's existence, some students proclaimed that they could now "come out of the closet," meaning they could admit they were planning to be teachers. This remains especially important in California where few teachers earn a credential as part of their undergraduate course of study.

During Year Three, our outside evaluators from West Ed in San Francisco interviewed and surveyed both the faculty sponsors and selected students in these Clubs. They reported that some Club sites were challenged by irregular attendance by students, who sometimes have scheduling conflicts from coursework or from work responsibilities. But, they also reported that, "Club members we interviewed were enthusiastic about the Future Teacher Clubs and expressed strong interest in continued participation, if their schedules allowed. At the very least, the clubs provided a sense of community that enhances the student experience. Students reported a greater appreciation for teachers and teaching."

C. Recruitment of Future Teachers:

Over the six year course of the (initially funded) Project, we tried several approaches to attracting more students into teaching. Some worked and others did not. The most effective approaches were the establishment of Future Teacher Clubs and giving interesting presentations in introductory science and math classes at our colleges and universities. The Future Teacher Clubs provided an outlet for students "just considering" teaching to learn more about being a teacher, to meet young and established teachers, to visit schools, and to meet other students who were planning to become teachers. The classroom presentations were given by a team of two highly skilled science teachers from our local high schools. They used magic tricks as a motivational introduction, followed by explaining the positive aspects of being a teacher and why they had spent thirty-some years in the career. Interested students would remain after class in order to talk with the presenters in person. We know that these two approaches attracted students into teaching because we routinely ask students who apply to our credential programs how they

became interested in becoming a teacher. By about Year Three in the Project and beyond, we began seeing students who said a pivotal decision was based on participation in the Clubs and/or having seen one of our recruiting presentations.

Approaches that didn't work well enough to continue them include: radio advertising, newspaper advertising, having a presence at Career Fairs, distributing posters and notices around campus, and offering scholarships for Teaching Scholars (more about this below). Note that posting notices about Future Teacher Club meetings was useful in informing people that the Clubs existed and were going to meet. However, notices pointing out that there was an abundance of teaching positions in the local area, or that we awarded scholarships to talented students didn't appear to draw in "new" people who hadn't already thought seriously about teaching as a career. We were especially disappointed that our presence at Career Fairs did not result in more applicants, given our local situation. Our one week of running radio and newspaper ads to attract people interested in teaching resulted in only two phone calls, and neither of the two people subsequently enrolled with us.

During the years of MASTEP, we experienced a severe shortage of science and math teachers. Indeed, most of the newly hired teachers were on Emergency Teaching Permits, meaning that they had no prior education in how to teach. Thus, most candidates were first hired by a school district, and later they contacted us to enroll in the necessary teacher credential program. To help these new teachers and take advantage of the situation, we embarked on an aggressive recruiting campaign through the Human Resources Departments of local school districts. We were able enroll many of these new teachers in our courses during their first semester in teaching. Because we have evidence that over 90% of these people have remained in teaching over a several year period, we believe that our early recruitment efforts contributed to helping these inexperienced teachers to survive and thrive in classroom teaching. A major complicating factor in all of our recruitment efforts had to be the high salaries paid by local industries to attract STEM graduates. High salaries are very attractive in an area with extremely high housing and cost of living expenses. For several years running, beginning salaries in industry were nearly three times what a new teacher makes.

Overall, our experiences appear to indicate that it's possible to recruit some undergraduates into careers in teaching in our area, but the large pool of STEM professionals already have their minds made up about teaching. Most have no interest in being a K-12 teacher, and the few that do seek out the opportunity without having to be recruited. Based on our interviews with such "re-entry" students, they elect to switch into a teaching career either when they have lost their prior job or when they have become too disinterested in their current job to continue.

Interestingly, once these professionals and the undergraduates who enter teaching become classroom teachers, most of them remain committed to teaching for a longer time than what is reported nationally, at least the graduates from the science credential program at San Jose State. As mentioned above and in the "activities" section, the MASTEP leadership at San Jose State University embarked on a project to determine the rate of retention in secondary science classrooms of MASTEP-educated science teachers. Our 2001 results (based on a 95% return rate) indicated that 92% of the new science teachers have remained in teaching (1996-2001 graduates). Naturally, the faculty at San Jose State want to take some credit for this remarkable retention rate, but part of it might also be that only highly committed people who are willing to forego high salaries elect to become teachers in our region.

For Years Two-Six of our Project, NSF awarded MASTEP $100K per year to award scholarships to talented "Teaching Scholars." We gladly accepted the scholarship money, and our Teaching Scholars Committee diligently oversaw the competition for the scholarships. NSF offered the funds partially on the assumption that more "highly talented" students in STEM disciplines could be attracted into teaching and away from other career pathways. That didn't work in our Project. We certainly were able to award all of the scholarships to highly talented students, but virtually everyone of them had already chosen to pursue a teaching career. Only a mere handful of students who accepted a scholarship were attracted to the money, and most of these few decided against going into teaching eventually. In our region at least, it seems once again that future teachers are not chasing money, even scholarship money. We regard this attitude in our teachers as most noble since it speaks to the commitment to teaching inside of these people.

This is not to say that the Teaching Scholarships served no important purpose. Overwhelmingly, our future teachers commented on how complimentary it was of the NSF and MASTEP to provide such financial assistance to students studying to be teachers. The scholarships made all of the students feel special, feel valued by society. Given the negative press that teachers and teaching often get, the students felt that the MASTEP Project and the scholarships legitimized the important career of K-12 teaching. Thus, we in MASTEP applaud the NSF for creating the Teaching Scholars Program, even if the initial premise of recruiting outside talent into teaching was not realized in our case.

D. New Teacher Support Network:

We sponsored NTSN's at two locations: San Jose State and San Francisco State Universities. Because each Network was overseen by a different Director, the activities varied between sites; however, the responses of the participants were generally the same. For the first two-three years of MASTEP, our Support Networks were about the only such activities for new teachers in our region. Consequently, we had widespread participation in Network activities in these early years. The high level of attendance at functions and the personal feedback we received indicated to the MASTEP leadership that the networks were valued and helping to guide our new teachers into their careers as highly effective classroom teachers.

During Year Three of MASTEP, our outside evaluators from West Ed in San Francisco specifically monitored our New Teacher Support Networks through review of reports, interviews with NTSN sponsors, as well as interviews and surveys conducted with NTSN participants. They reported, ". . . at the end of the 1997-98 academic year it appeared that both campuses were on the right track toward providing new teachers assistance, professional development, and support that may encourage them to continue teaching. Nearly all novice teachers surveyed reported that they *agree* or *strongly agree* that they would like to participate in more NTSN activities. And, more importantly, all 22 new teachers surveyed reported that they planned to continue teaching the next year." WestEd also concluded, "New K-12 teachers of mathematics and science report feeling *fairly well* or *very well prepared* to implement reformed practices."

During Years Four-Six of the Project, a new climate developed for new teachers. Most importantly, the State of California expanded the funding for the BTSA (Beginning

Teacher Support and Assessment) Program, such that virtually all reasonable sized school districts were eligible to obtain State funding. Additionally, several of our large and prominent school districts began devoting some of their own funds to supporting their new teachers. In the San Jose State service area, the University of California at Santa Cruz obtained extensive funding (including from the NSF) to work with new science and math teachers. In San Francisco, the Exploratorium (a large informal education institution) obtained funding to work with new science and math teachers. The effect was that most new teachers were now required to participate in district-sponsored activities, plus they had multiple other opportunities as well. The outcome was that a smaller percentage of MASTEP graduates elected to be active in the MASTEP NTSN's compared to earlier because some of the new teachers were already being overwhelmed by required commitments in other programs.

Those new teachers who have elected to remain active participants in our Networks continue to be well served (note that MASTEP received a "Follow-on" grant from NSF to continue some activities through 2004, including some Support Network activities). We routinely solicit survey feedback from the teachers who attend our activities, and the feedback continues to indicate that the activities are highly valued.

E. Teaching and Learning Conferences for Faculty:

In our initial proposal to obtain funding for MASTEP from the NSF, we proposed the plan to educate our faculty about new pedagogical approaches prior to asking them to propose curricular changes in their courses. This plan was not received well at NSF at the time because the prevailing expectation for a grant proposal was that virtually all courses to be revised or developed were to be described in great detail. The attitude was why should we fund a proposal that doesn't explain in detail exactly what will be done and who will do it? Reviewers were instructed to expect such detail, and Program Officers criticized anything less.

We disagreed that such a plan was the best way to accomplish fundamental and creative reform in STEM courses. Our considerable experience with educational reform efforts had convinced us that when most faculty revise their courses, they make only content substitutions. Less timely or current information is replaced by newer discoveries, but approaches to instruction and assessment (i.e., pedagogical techniques) seldom change. Thus, the instructional pattern has long continued to be lecture-oriented, with most laboratory activities being

"verification" exercises (or what some of us call "recipe-following" exercises). Importantly, educational research over many years has determined that improvements in student learning largely are the result of pedagogical change, not content substitutions. But, how can anyone expect faculty to introduce new pedagogies into their teaching when they've never even heard of them, much less become convinced that they might work?

Thus, we argued strongly to NSF that a new model was necessary, a model where faculty first learned of new approaches to teaching and learning, followed afterwards by the faculty proposing how they would introduce these approaches into their courses. Under this model, it can't be clear up front which faculty will elect to adopt these new approaches; and, thus, it also isn't clear up front exactly what courses the "reformed" faculty will choose to revise. Consequently, we proposed to sponsor competitions for the funds to be used for course revision/development. The most worthy proposals would be funded, with criteria in place for receiving funding (such as, incorporating multiple new pedagogies and assessment practices into courses that had many future teachers). NSF ultimately relented and funded us to try the new model, but considerable skepticism remained over our approach. We believe that the following results support the conclusion that our model was a successful one.

Over 400 different faculty participated from the six campuses in our workshops highlighting new pedagogical approaches. These faculty were the core of those who were funded to do extensive course development or revision. Each course funded had to explain in detail what combination of new pedagogical approaches would be incorporated into the course, and explain why this was desirable.

Our WestEd evaluators reported at the end of Year Three: "Faculty became more familiar with the use of *active learning strategies, multimedia instructional tools, cooperative learning groups,* and *problem solving* as instructional practices to be applied in post-secondary classrooms. 96% of faculty responding to a survey were stimulated to implement new approaches in their teaching. Faculty were more aware of the important role they played in the preparation and recruitment of future K-12 teachers. Faculty reported that changes in instructional practices produced increased student engagement, greater interest in content, improved attendance, and deeper learning." This conclusion was reiterated in the end of Year Five Evaluation Report.

F. Course Revisions at the College and University Levels.

Over the years of MASTEP about 300 faculty received support to participate in course development. However, the total number of faculty impacted was over twice this number because many of the courses revised became taught by other faculty who adapted the new course formats and approaches. This was especially true of brand new faculty hires, including temporary faculty, who were mentored by permanent MASTEP faculty. By about Year Four of the Project, some of our Community Colleges had so institutionalized the new pedagogical approaches that the faculty were talking about MASTEP as "been there and done that."

Our WestEd evaluators concluded at the end of Year Five: "The Faculty Development initiative exerted a great deal of influence on how science and mathematics faculty viewed instruction. Faculty learned that there is a body of research on education, on instructional practices, and student learning. People, whose training and tradition are focused on looking at data for making decisions and taking action, acquired a new interest in the instructional side of their responsibilities and learned that there was a body of evidence behind the pedagogy emphasized by MASTEP. Presenting new ideas about instruction through workshops facilitated by university faculty who had actually conducted related action-research in university classrooms was the key to convincing many people that new strategies could work in their own classes. People whose life's work involves using data to make decisions require this level of "proof." The head of the Teaching and Learning component spent a considerable amount of time and energy in researching who might be the best candidates to convince the MASTEP audience; her efforts paid off."

As a summary statement about the findings about the MASTEP Project, we relate the following conclusions from our National Visiting Committee (NVC). Our NVC consisted of about eight national experts in science and mathematics, from education faculty to science and math content experts. This distinguished group visited us each year to assess our activities. Near the end of the original five year grant, they prepared a report that contained the following observations:

"Based on (the stated MASTEP objectives), the NVC is pleased to report that the overall state of the project is strong and successful. Support for this assertion is contained both in the individual campus reports and the Evaluation Report by WestEd.

The overall feeling of the committee was that much energy and dedication of the PI's lead faculty and administrators from each institution, and students, contributed to the success of the MASTEP collaborative. There were strong sentiments that the collaborative has set in motion a true collegial relationship amongst the individual campuses. It is the general conclusion of the committee that the communication between faculty, departments, and campuses was worth the grant dollars from NSF. The systemic change in a large number of courses affecting over 8 thousand students is a wonderful testimony of MASTEP's influence.

Overall conclusion of the NVC is that the MASTEP project has really gained momentum . . . As we all know change comes very slowly, if at all, in academe. However, the two state universities with linkage to the community colleges have achieved beyond imagination."