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ABSTRACT

This paper describes the Partnership for Excellence in Teacher Education (PETE), which promotes reform in mathematics and science teaching and learning in regard to preparing mathematics and science teachers. One of PETE's goals is to redesign teacher education curricula for selected courses. The PETE collaborative formed a Professional Development School (PDS) learning community among colleges, schools, and students. Teams of mathematics, physics, and education faculty integrate activities and curriculum into PDSs. University classes are taught in public schools, with preservice educators teaching content and practicing pedagogy in the classroom. College faculty observe student teachers' performance and provide feedback. Student teachers keep reflective analysis logs. The integrated team-taught field model assumes that the program will increase students' mathematics and science content knowledge, pedagogical skills, and level of teaching performance and will change their negative perceptions toward mathematics and science learning and teaching. Overall, preservice teachers felt the pilot programs provided a good setting for learning to teach mathematics and science. They preferred meeting in schools and felt the relationship with university professors provided more mentoring than did traditional university teaching. Preservice science teachers had more positive attitudes about their ability to teach than did preservice mathematics teachers. (Contains 36 references.) (SM)

Students' Perceptions of Cross-Disciplinary Team Teaching On Site at a PDS[1]

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All states and schools will have challenging and clear standards of achievement and accountability for all children, and effective strategies for reaching those standards.

President's & Secretary's Priorities. January 2000: Quoted on the US Department of Education's web site

When historically recounting our nations' drive toward educational reform, the last decade of this century will undoubtedly be identified as the time when a concentrated press for national education standards emerged (Glaser & Linn, 1993). Forty-nine states and a number of urban districts have set standards for what students should know and be able to do at various points in their school careers. About fifty percent of the states hold schools accountable and apply sanctions to those whose students fail to meet the standards. At least one third of them require students to score at designated levels on tests for promotion or graduation. There are few issues more important to education policymakers today than the development of standards that fundamentally define what students should know and be able to do - -and how these students should demonstrate their knowledge and skills (Marzano & Kendall, 2000).

Diane Ravitch, former Assistant Secretary of Education is commonly credited as one of the main influences in the modern standards movement. Ravich (1995) compares education to other professions which clearly maintain standards by which to judge success. She maintains that standards can improve the effectiveness of American education by clearly defining what is taught and what kind of performance is expected.

To work with standards-based teacher education, there must be public school interest in the efforts. School and university faculty must be knowledgeable about standards and willing to collaborate. There must be mutually agreed upon student teaching components and other field experiences so student teachers benefit from their training (Knudson & Wiley, 1997). The most critical element facilitating implementation of standards based instruction was the effort by policymakers to balance between new goals and traditional teaching methods and subject areas. Contrary to concerns that

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standards-based reforms would overextend state and federal authority, in practice the policies fit well within the decentralized American tradition (Massell & others, 1997). How standards-based instructional reform fits into the university environment allows much speculation and room for further exploration. University faculty play a major role in the implementation and acceptance of standards-based instruction.

In one study, researchers collected data via interviews with principals, teachers, and students and observations of mathematics and science instruction, emphasizing the systemic reform initiative's impact in the schools. Most elementary and middle school teachers felt the standards-based reform initiative had a great impact, but high school teachers saw little use for it. Students reported enjoying mathematics and science more and applying themselves more when challenged. Observations of classroom practice showed that much instruction was **not** standards-based, though at all levels in both disciplines there were some strong examples. Principals recognized the need for multiple methods of teaching and for keeping teachers current regarding instructional materials and the need for teacher collaboration but mentioned lack of time during the day (Huinker, Coan, & Posnanski, 1999).

Interdisciplinary instruction is equally concerned with the learning processes as well as skills, and ways of knowing that are unique to the different disciplines, subjects, or domains. In contrast, disciplinary subject centered instruction focuses almost exclusively on content and aims largely at helping students amass facts and general information (Wood, 2001). Inquiry and scientific investigation are useful in interdisciplinary studies. Interdisciplinary work supports Dewey's (1933) advice that equal importance be attributed to content and process. Students are expected to amass facts and develop concepts while they practice important academic learning processes that will become the models for later exploratory behaviors (Gardner, 1993) and gain insights about and practice different ways of knowing. In addition, students have many meaningful opportunities to practice their teaching of mathematics while they are involved in authentic investigations of learning and teaching.

Partnership for Excellence in Teacher Education (PETE)

The Partnership for Excellence in Teacher Education (PETE) is a NSF funded project to promote reform in the teaching and learning of mathematics and science in regards to the preparation of teachers who will teach mathematics and science. One of the four main goals of the PETE program is to redesign the teacher preparation curricula for selected education, mathematics, and science courses to reflect current research on learning and teaching. Current research on teaching and learning based on mathematics and science reform cannot be fully explored until a standards-based program with a strong content and pedagogy foundation is established. The PETE collaborative has formed a unique learning community among colleges, schools, and students. The Fall/Spring pilot programs consist of teams of teachers from mathematics, physics, and education integrating their activities and curriculum on site at professional development schools. The university classes will be taught in actual public schools and the university students will go directly into classrooms (one hour per class block) to teach content and practice pedagogy. Faculty from both the Colleges of Science and Education with input from teachers will observe their teaching performance. Immediate written feedback will

be given the university students and they will in turn keep reflective analysis logs of their experience in class and classrooms. The pilot is based on the following underlying assumptions.

- Traditional teacher education programs and student teaching experiences do not provide enough time for preservice teachers to teach mathematics or science in actual classrooms. This limited experience in mathematics and science teaching reinforces the low confidence level of most teacher education students in their ability to understand and teach these subjects.
- The field-based pilot will provide university students an opportunity for immediate application of their knowledge and skills in actual classroom settings in a real public school environment with feedback from university teams and public school teachers.
- The team teaching between faculty in Colleges of Education and Science will integrate mathematics and science concepts with an active application of teaching and learning.
- The project will develop an understanding of the problem-solving process from the cognitive point of view, using problem solving interview protocols with peers and public school students.
- The project will develop an understanding of the social aspect of learning through analysis of video taped recordings of classroom interaction.
- Learning depends upon the match between facts and skills that is modeled and practiced by university faculty teaching the courses.
- Transfer and application of knowledge can be improved by helping students become more aware of themselves as learners who actively monitor their learning strategies, resources, and teaching.
- Active and direct collaboration between university faculty from different colleges and public school faculty will facilitate the integration of concepts traditionally taught at the university with "real world" learning and teaching in the classroom.

Teacher Assessment Model

The integrated team taught field pilot model is based on the assumption that the program will increase students' mathematics and science content knowledge, their pedagogical skills and level of teaching performance to help them become effective teachers of mathematics and science, thereby building the foundation for effective teaching. The illustrated model, originally designed for mathematics shows the relationship between the three elements -- content knowledge, pedagogical skills, and level of teaching performance, and how these three elements integrate and build to guide the student into becoming an effective teacher. The teacher plays multiple roles and at any given time may be at different levels in each category.

Organization of the Team Teaching Model Two different models are in place in the pilot program. For simplification of identification, think of them as the math block and the science block. The term block refers to a group of classes that students are required to take in the same semester and that are scheduled in a straight "block" of time. This

scheduling allows for more flexibility in instruction when teachers are team teaching as the content is not taught in isolation.

The Mathematics Block: Properties of Real Numbers, Mathematics Methods, and Curriculum Development. The mathematics block combines three courses, one from the College of Science (Mathematics Department) and two from the College of Education. The university students are enrolled in the first semester of their senior year of their college program which is called Block I. The faculty members teach their classes in a local middle school with the exception of the computer work done Wednesday morning from 8:00-9:30 on the university campus. The classes are on Monday and Wednesday from 8:00-12:15 and all three faculty are there for the entirety of the allotted time. Each course represents one of the components from the theoretical model described on the previous page. The mathematics course (content) is taught using a project approach to learning. The mathematics methods course (pedagogical skills) reinforces this approach to teaching by adding standards-based instruction, reflective analysis, and approaches to assessment. The curriculum course (performance) requires application of concepts and skills learned in the other courses.

The courses have combined assignments with each instructor grading the assignment according to his or her expectations. Common assignments for all three courses include a videotape of the university student teaching, a reflective essay, written journals containing explanation of the student's thinking as they work through the mathematical problems and the teaching act, and a portfolio of their work from the semester. The grading scale consists of a "minus", "check", and "check plus" assigned to each project with a redo option. An established number of "check pluses" is considered an "A" and so forth.

The last hour of each Wednesday session, the university students move into classrooms in the middle school and the adjacent elementary school and teach mathematics lessons modeled by the university faculty. During this teaching segment the university faculty, along with the classroom teachers observe the teaching behavior and make notes concerning content and teaching skills. Suggestions for improvement are provided for each student. Before the university student receives the written feedback they have a short reflective period where they self analyze their teaching and plan for ways to improve the lesson as they perceived it. Then comparisons are made between their perceptions and the university and school faculty expectations. As the university students gain confidence in their teaching they take over the design of the lessons and turn in lesson plans prior to their teaching. On Mondays students from the middle school mathematics classrooms come into the portable unit provided by the school for the teaching of university courses and are interviewed concerning their conceptual understanding of mathematics and mathematical problem solving strategies. The field placement of these students is widespread through out the local school districts

Strategies for changing students' perceptions

A majority of the elementary pre-service teachers enter the blocks with previously developed negative perceptions and attitudes toward the learning and teaching of

mathematics. In order to change this perception and make it more positive, we use the following strategies:

- Mathematically friendly teaching philosophy
- Conceptually rich instructional sequence
- Problem solving peer/students interviews.

Below we will discuss each of them in more details. Our team teaching and research philosophy is based on the foundations of Activity Theory and Developmental Approach (L. Vygotsky, R. Skemp, etc.). We firmly believe that effective teaching is a student-centered activity. In actual university classrooms or auditoriums, emphasis should be on learning rather than teaching: we are not supposed to teach/lecture only, we are supposed to help students to learn. We consider our main role as facilitating the engagement of students to the thinking process by posing challenging problems and creating an atmosphere of mathematical and pedagogical exploration and sense making. In order to achieve this goal, we use different strategies to encourage students' learning and thinking (e.g. project-based instruction, open-ended approach, cooperative learning groups, problem solving peer interviews, multiple representations including modeling and technology).

We do believe that students construct their own understanding in an active learning environment (e.g., A. Leont'ev, E. von Glasersfeld). As teachers, we cannot simply transmit ideas to passive learners, knowledge cannot be poured into students as if they were empty jars. Each student comes to our block classes with his or her unique experience, understanding, beliefs, attitudes, and own "collection" of ideas about learning and teaching mathematics. We try to use students' unique experience and ideas as a springboard to construct their conceptual understanding of mathematics as they "wrestle" with challenging problems, projects, and activities, discuss ideas and solutions, use different representations to explain their methods, and reflect on their learning. In other words, we try to create challenging but, at the same time, mathematically friendly learning environmens where they realize that each of them can learn math and learn how to teach it successfully.

In order to help students change their negative perception and attitude towards math, we also share with them our common philosophy of teaching and learning of mathematics. Main points of this philosophy are: (1) do not be afraid of making mistakes but be afraid of repeating them; (2) the process of doing mathematics is not less important than its result; (3) it's better to solve one problem by three methods than three problems by one method; (4) the purpose of mathematical problem solving is not to get the right answer but to promote students' thinking; (5) giving right answers to students is to do their thinking for them;(6) it doesn't matter if you know how to solve 100 problems, it does matter how you approach the rest of them; (7) fun is a derivative of challenge; (8) what we assess is what we value. Another way to encourage elementary and middle school pre-service teachers to create mathematically friendly learning environment in the actual classrooms is to implement a conceptually rich instructional sequence adopted from recent TIMMS studies, which includes following steps:

1. Posing a problem (the teacher poses to the class one challenging, rich, multi-step problem/activity/project, which aims at high-order thinking skills development).
2. Individual work on the problem (each student tries to figure the problem out on his or her own for 3 to 5 minutes using concrete, pictorial, or symbolic representations as needed).
3. Work in pairs and small groups (students share how they are working on the problem with their peers in small groups for 8 to 10 minutes. Each group decides which approach of the students is the one they want to use together).
4. Presentation of the group's solution (each group presents what they have done and their thoughts about how they are reasoning. This is done on the board/poster/overhead in front of the whole class. Every group member tries to contribute to the group presentation. Each solution stays on the board until all groups are done with their presentations).
5. Whole class discussion (the whole class then decides which approach or approaches seem best. The teacher keeps asking questions if students seem to need help in making a decision. The teacher guides the students to correct reasoning patterns if all solutions prove to be incorrect).
6. Extension and overview (the teacher guides and helps the students to make a generalization of the problem (e.g., to find a general formula/solution, to make connections, to enrich the activity). As an extension to some activities, students also write in individual journals what they learned from the lesson, including rationale for alternative solutions if there is more than one way to arrive at solutions).

The problem solving peer interview is an effective way to promote pre-service elementary teachers' understanding of the problem solving process. During the semester each of the pre-service teachers have an opportunity to interview peers and school students as well as being interviewed by their peers. The main purpose of this assignment is to encourage the students to reflect on the process of problem solving and reasoning in a specific mathematical content area. They bring to the class for each interview session 2-3 challenging problems. Arrangements are made for students to conduct the interview during class time. After conducting the interview, the interviewer writes a protocol of the interview he or she conducted. The protocol contains reflective information on the thinking process which was observed and analyzed: the problem posed; the questions asked; how the problem was solved; what techniques have been used; what manipulatives, visual tools and models have been used; how the interviewee felt during the interview; how the interviewer felt during the interview; what the student learned from this experience both as an interviewer and interviewee, etc. This experience helps pre-service teachers realize the importance of the problem solving process, to understand and value the uniqueness of individual's thinking process, to be aware of individual learning styles, to be ready to face the phenomena of learning diversity in the real classrooms, etc.

Middle School Site. Since it opened in 1987 the Middle School has played an important role for its community by implementing language acquisition programs and hiring

Spanish speaking teachers to accommodate the large flux of students coming from Mexico. A large percentage of students are first and second generation Americans. Student enrollment is 90.8 percent Hispanic. African American students comprise a 0.8 percent of the student body while 8 percent of the students are White. 85% of the students are considered disadvantaged. The schools supports the pilot study by providing space and classroom time for student teachers to teach and learn mathematics as they implement their mathematics lessons with middle school students.

The Science Block: Physical Science, Science Methods, and Critical Pedagogy: The Science Block. The science block combines three courses, one from the College of Science and two from the College of Education. The physical science course is taught by a nuclear physicist, one education course is taught by a science methods instructor, and the third course is a social science course taught by an education professor. The university students are in their final semester of their college program that is called Block II. Faculty members teach their classes in a local elementary school and the faculty are there for a minimum of six hours a week. The sample of university students is voluntary and all participants are well aware of the research, expectations, and freedom to leave this science block and transfer to another group of classes. The classes are on Tuesday and Thursday from 8:30-11:30 and Tuesday afternoon from 1:30-3:30.

The physical science course is taught using a hands-on active inquiry approach to learning. The science methods course reinforces this approach to teaching adding standards-based instruction, reflective analysis, and approaches to assessment. The course includes journal writing and pre- and post- videotaped segments of each university student teaching in classrooms. The actual teaching is balanced between the faculty depending on the expertise concerning lesson topics. The last hour of each Tuesday and Thursday morning session, the university students move into classrooms and teach science lessons modeled by the university faculty. During this teaching segment the university faculty, along with the classroom teachers observe the teaching behavior and make notes concerning content and teaching skills. Suggestions for improvement are provided for each student. Before the university student receives the written feedback they have a short reflective period where they self analyze their teaching and plan for ways to improve the lesson as they perceived it. Then comparisons are made between their perceptions and the university and school faculty expectations. As the university students gain confidence in their teaching assume responsibility for the design of the lessons and turn in lesson plans prior to their teaching. All students teach two science lessons per week. 92 percent of the university students are assigned for their field placement (similar to the traditional student teaching concept) in the same school where the pilot courses are taught. The other 8 percent of students' are in close proximity to the elementary school.

Assessment in this program includes pre- and post- content tests designed by the individual university faculty based upon their course expectations. Video segments of the students teaching are recorded the first weeks of teaching and the last weeks for comparison concerning the three theoretical model components (content knowledge, pedagogy, and teaching performance). Weekly physical science tests are given on Thursdays. The lesson plans and reflective teaching sheets are graded weekly and returned. A final examination will be designed combining both course expectations.

Strategies for changing students' perceptions

The approach is similar to the mathematics block teaching. The majority of the elementary pre-service teachers enter the blocks with previously developed negative perceptions and attitudes toward learning and teaching of science and little awareness of what they have learned in their science courses. In order to change this perception and make it more positive, we use the following strategies:

- Science friendly teaching philosophy
- Conceptually rich instructional sequence
- Close collaboration with the school site and teachers

The same philosophical background as the mathematics block is the base of the science block We use the following instructional sequence in the science block.

1. Posing a problem (the teacher poses to the class one challenging, rich, multistep problem/activity/project, which aims at high-order thinking skills development).
2. Small group work on the problem. This runs anywhere from 20 minutes to 1 hour depending on the project.
3. Written analysis of their work on data sheets or in science journals.
4. Application in the classroom of the teaching using standards-based inquiry-based science kits or other inquiry-based science lessons..
5. Reflective analysis of their teaching.
6. Whole class discussion (the whole class then decides which approach or approaches seem best. The teacher keeps asking questions if students seem to need help in making a decision. The teacher guides the students to correct reasoning patterns if all solutions prove to be incorrect).

To develop an understanding of how lessons fit into the classroom, how the classroom fits into the school, and how the school fits into the community, student interns examine, reflect and discuss the overarching issues in education in their critical pedagogy course. It is this course that student interns learn about working with and dealing with parents and see how the school is deeply connected (or not) to the community in which it resides

The Elementary School Site. The school was build 30 plus years ago and to this date has only had three principals to date. The student population is 98% Hispanic and 85% disadvantaged. A large percentage of the students are first generation Americans, their families recently immigrated from Mexico. Most of the teachers had started teaching in this school and had been there for several years. Few of the teachers had been back to school or pursued new information on teaching and learning. The principal and the teachers met and decided on ways to change the climate of the school. They all agreed that they needed to recommit to progressive education. The campus became an open campus where parents can come and work in the schools, meet, and communicate concerns openly. The school took on the commitment of working with large groups of interns from the university and piloted the on-site teaching of university courses. The

school and program soon developed "a cycle of reform" environment. The university interns were learning from the school, the teachers were learning from the interns, and the university faculty were learning from all concerned.

The school provided a science lab for the university courses and designated a classroom for university use. Science was rarely taught at the school until the science block moved in. Involvement with the program was voluntary and at first there were only a few teachers working with the project. Currently all teachers are including science in the weekly lessons and there is 100% participation in the program.

The University Student's Perceptions of the Pilot Programs

> *W can better apply concepts that we learn from our university classes into the classroom. I feel it builds a community into the school....a community of professors, teachers, and students. This program will also inspire students to go to college.*
>
> *Block II Student Fall 2000*

After initial discomfort and criticism, the students generally feel that the pilot programs are successful in providing them with the instructional setting to learn mathematics and science and to learn how to teach math and science. All of the students prefer meeting in the schools and perceive the relationship with university professors as providing more mentoring than traditional university teaching. Block I (mathematics) students evolve from extreme discomfort when teaching a math lesson to a higher level of confidence in their abilities to teach mathematics. The mathematics block students frequently complain about having to teach something they do not know. Early in the semester they express a high level of frustration when they are required to meet the national standards in their teaching and lesson preparation. Much of this stems from their negative attitudes towards mathematics and their perceived inability to do math, much less teach it. Slowly they gain confidence in their own ability and by the end of the semester they are generally capable of presenting a standards-based mathematics lesson. Most of the mathematics block students are, at first, shocked when we give them feedback as to their teaching skills. It seems that the students assume that all they have to do is show up and talk. With feedback from the faculty, they start to understand the complexity of the teaching act. Generally the students appreciate the time and effort the university faculty put into the program.

The science block students have a more positive attitude concerning their ability to teach science and are more comfortable in classrooms having spent time in the schools as interns during the mathematics block. They do have access to several standards-based inquiry-based science kits and agree that science is more "fun" than mathematics. The confidence level increases each week as they work in the classrooms with children. They teach twice as many lessons in this block as in the mathematics block and are in their last semester before graduation. The science block students feel the experience "truly prepares us to be a first year teacher." Generally, the students like the freedom to try and learn from their mistakes and successes. They feel like professionals and almost all agreed that this is the best way to train teachers. The close association with teachers and school personnel allows them to "gain confidence and build trust in the school culture."

The UTEP field program requires almost 600 hours of work in classrooms as the students progress through their degree plans. While these hours are valuable the students often spend time grading, copying papers, and other clerical types of activities assigned by their teachers. They rarely get the opportunity to teach science or mathematics. The pilot programs insure that the student interns have experience teaching in these crucial fields and hopefully help ease their fear of mathematics and science teaching ... and when they are in their own classrooms the fear many K-12 students have when it comes to mathematics and science.

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