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NSF-sponsored Conference
The Integral Role of the Two-Year College in the Science and Mathematics Preparation of Prospective Teachers

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Editor’s Note

This special issue of *The Journal of Mathematics and Science: Collaborative Explorations* is devoted to the proceedings of a National Science Foundation conference, conducted in Washington, D. C. on March 12-14, 1998. The conference, conducted by the Virginia Collaborative for Excellence in the Preparation of Teachers, was entitled *The Integral Role of the Two-Year College in the Science and Mathematics Preparation of Prospective Teachers.*

In order to better understand the outstanding contributions of certain community colleges to the preparation of teachers and to better understand what is possible in all community colleges, a national competition was conducted to identify eleven exemplary two-year college programs. Representatives of each of the winners in the competition were invited to participate in the conference and were recognized at the National Academy of Sciences. Papers from the recognized programs were solicited and reviewed through the normal reviewing process of the journal. They appear in this special issue.

Faculty and administrators from the recognized programs joined faculty and administrators from other two-year and four-year colleges, representatives from national disciplinary professional organizations, current K-12 teachers, and pre-service teachers from two-year colleges. They discussed ways to fully utilize community colleges in order to meet the need for a teaching force well prepared in science, mathematics, engineering and technology. The recommendations of this conference to the National Science Foundation are also included in this special issue.
THE INTEGRAL ROLE OF BOROUGH OF MANHATTAN COMMUNITY COLLEGE IN THE MATHEMATICS PREPARATION OF PROSPECTIVE TEACHERS

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Borough of Manhattan Community College (BMCC) of the City University of New York (CUNY) is the only two-year college on the island of Manhattan. This institution has a diverse population of approximately 17,000 students who attend day/evening/weekend classes. Over 1,000 students are enrolled in the Early Childhood Education (ECE) Program. Each year, approximately 300 new students select this area of concentration. The dropout rate is less than 14%. The ECE Program prepares students for elementary education programs at four-year institutions. The program also offers two career areas of study: Infant Toddler and Pre-School.

This article will discuss how high quality teacher preparation at BMCC is promoted through mathematics coursework recommended by the NCTM and AMATYC for prospective elementary school teachers, the importance of technology in providing enriching pre-teaching experiences, collaboration with four-year institutions in teacher preparation efforts, and the importance of special teacher preparation of underrepresented populations for underrepresented populations of New York City.

Borough of Manhattan Community College (BMCC) of the City University of New York (CUNY) is the only two-year college on the island of Manhattan. There are approximately 17,000 students who attend day/evening/weekend classes. Many BMCC students are the first in their families to attend college. Over 90% are non-white; 65% are female; and approximately 75% of entrants require some form of remediation in mathematics. The average student is 21 years of age [1]. Many dialects of various world languages are spoken by the diverse student population.

Over 1,000 students are enrolled in the Early Childhood Education (ECE) Program. Each year, approximately 300 new students select this area of concentration. The dropout rate is less than 14%. In addition to preparing students for elementary education programs at four-year institutions, the ECE Program offers two career areas of study: Infant Toddler and Pre-School. Students may thus choose to work directly with children in elementary/early childhood education settings that include infant care, Head Start Centers, pre-kindergarten, kindergarten, elementary schools, day care, and hospitals for the physically handicapped and
learning disabled. Opportunities also exist for students to work for educational and commercial television. Students interested in the marketing field may use their ECE knowledge in sales and buying of such products as toys, children’s books and materials, and children’s clothing.

This article will discuss how high quality teacher preparation at BMCC is promoted through mathematics coursework recommended by the NCTM and AMATYC for prospective elementary school teachers, the importance of technology in providing enriching pre-teaching experiences, collaboration with four-year institutions in teacher preparation efforts, and the importance of special teacher preparation of underrepresented populations for underrepresented populations of New York City.

Promoting High-Quality Teacher Preparation through Mathematics Coursework Recommended by the NCTM and AMATYC

Mathematics for Elementary Education I (MAT 114) is a four-credit course that covers mathematics recommended by the National Council of Teachers of Mathematics (NCTM) and the American Mathematical Association of Two-Year Colleges (AMATYC) for prospective elementary school teachers. The course topics include sets, problem solving, logic, numeration, real numbers, and number theory. MAT 114 focuses on a learner-oriented approach to teaching mathematics. Emphasis is placed on mathematical concepts and skills, as well as techniques of inquiry and critical thinking. The course includes a survey of elementary mathematical concepts with appropriate materials to assist teachers in the classroom setting. MAT 114 meets the mathematics requirement only for students in the Early Childhood Education (ECE) Program. Students taking this course must have passed or been exempt from Basic Arithmetic and Elementary Algebra, and all remedial reading, writing and ESL requirements. The BMCC Mathematics Department currently offers three sections of this course each semester, providing for enrollment of approximately 75 students.

In accord with the NCTM standards [2] and the AMATYC standards [3], the course objectives are intended to promote student mastery of both mathematics content and mathematics pedagogy:

Mathematics Content:
- To develop knowledge of sets, problem solving, logic, numeration, real numbers, and
number theory from a higher viewpoint for students who intend to teach in elementary schools;

- To develop the power to communicate mathematically through reading, writing, and discussing ideas which require the appropriate use of the language of mathematics.

**Mathematics Pedagogy:**

- To be able to plan and utilize the most suitable approach (individualized instruction, cooperative learning, writing activities, etc.) for each type of lesson;

- To know how to determine which topics are best taught in small and which in large group lessons, how to develop challenging assignments, how to create an effective learning environment, ways to allow students to have time to reflect, how to promote student discourse, how to make connections with other branches of mathematics or other subject areas, and how to improve student attitudes toward mathematics;

- To consider alternative approaches in problem solving, the use of calculators and computers, and activities that promote students learning to value mathematics while developing confidence in their own mathematical ability;

- To undertake the initial steps toward professional development through self evaluation and peer interaction;

- To be cognizant of the most recent research and professional consensus about elementary mathematics education, and develop an inquiry-oriented and reflective attitude to the teaching process.

Because the population of students enrolled in this course has had little or no exposure to the type of teaching and learning recommended by the NCTM, one of the required texts for the course focuses on appropriate mathematics pedagogy and use of technology, *Mathematics, A Good Beginning (Fifth Edition)* by Troutman and Lichtenberg. To reinforce and extend college-level mathematics concepts and skills, the content textbook for the course is *Mathematical Ideas (Seventh Edition)* by Miller, Heeren, and Hornsby. Because few of the students can afford to purchase both textbooks, the computerized version of the content textbook, complete with tutorials, is utilized in a Math Lab setting.

**Reflecting National Mathematics and Science Standards and Providing Enriching Pre-Teaching Experiences**

What makes this course innovative is that the mathematics content and pedagogy are
integrated with technology. Students learn individually or as part of a cooperative group by working with actual manipulative materials, or with electronic materials that are a part of a mathematics software program. Such a format allows prospective elementary school teachers to learn mathematics and mathematical pedagogy in a way they have not been exposed to previously, a way that is consistent with the NCTM's Standards. The materials include attribute pieces, Cuisenaire rods, counters, base ten blocks, coins, scissors, paper clips, and rubber bands. The computerized version of Mathematical Ideas (Seventh Edition) is utilized during sessions scheduled each week in a Math Lab; this text version is also available for student use during "open" lab periods. Technology (elementary-level mathematics software, college-level mathematics software, and a variety of calculators) is therefore used not only to facilitate learning, review and practice but also to broaden the conceptual and procedural understanding that is crucial for effective pedagogy. Students are also assigned research projects that, for example, require them to obtain certain information about teaching mathematics from various World Wide Web sites or to present and videotape mathematics mini-lessons with small groups of children. Prospective teachers can thus begin their careers with increased awareness of the potential uses of technology through such courses as MAT 114. These courses incorporate a wide range of experiences in the educational uses of technology and set general expectations for prospective teachers to judiciously use technology in their future teaching jobs.

MAT 114 students learn that mathematics is not a spectator sport, but a participatory one. They are expected to help each other both individually and collaboratively in small groups. Classroom discourse is encouraged to help students clarify mathematical ideas and develop abilities to communicate effectively using the language of mathematics. Both the NCTM and the AMATYC Standards advocate the use of activities that provide opportunities for students to learn by working in groups and by reading, writing and speaking to enhance mathematical communication skills. MAT 114 students are appropriately provided such experiences and also encouraged to adopt comparable activities in their own future classrooms.

The variety of materials used as embodiments of mathematical ideas facilitate the learning of those ideas in the MAT 114 classroom. Students use manipulatives that help to enhance their understanding and develop their abilities to construct mathematical knowledge. Appropriate materials are also used to emphasize that learning is unique to the learner, and
to show that multiple approaches to the same concept can enrich the classroom environment for every student. For example, a lesson that begins on an elementary level with individual and small group activities involving playful examination and sorting/classifying of attribute pieces or pattern blocks develops to incorporate college level concepts of set theory and logic. Cuisenaire rods, counters, and base ten blocks are used in later activities to review numeration systems and introduce college level concepts related to finite mathematical systems.

Thus, mathematical ideas needed for the development of an elementary school topic are introduced and developed using suitable concrete and/or pictorial models. This allows MAT 114 students to (re)learn the mathematics in a non-threatening manner, and helps them make appropriate connections between the elementary and college level content. MAT 114 students also grow to appreciate the connection between content and pedagogy that facilitates teaching with expertise and clarity. The prospective teachers are gradually introduced to materials that will benefit elementary school students when learning mathematics. The textbooks that emphasize the teaching/learning of elementary-level mathematics and college-level mathematics help put the activities into perspective. They provide background readings on pedagogical issues and various ways children learn mathematics; they include the construction of lessons, activities and exercises to extend pedagogical experiences and content knowledge.

To emphasize that mathematics is not limited to the physical boundaries of the classroom, students are asked to complete a variety of written projects such as publications research, teacher interviews, technological investigations, and conference reports. Prospective teachers must see the relevance of mathematics to help uncover it for their students. The projects provide opportunities for exploring the mathematics taught throughout the grades, sequencing within mathematical topics, comparing approaches used in various textbooks, and reviewing mathematical content. Reading professional mathematics journals such as *The Arithmetic Teacher* and *Teaching Children Mathematics*, evaluating software for elementary students, locating and collecting information from appropriate web sites - and sharing or presenting information for class discussions - are important for professional growth. These activities enable the prospective teacher to put mathematical ideas into the context of the classroom, reinforce that there is no one right way to teach mathematics, and allow for a continuation of dialogue of mathematical ideas and teaching strategies.

The role of the instructor varies throughout the MAT 114 course. At times the instructor
acts as a facilitator, posing open-ended questions, helping students answer their own questions, and generally encouraging the dialogue and investigation of mathematical ideas that characterize the excitement of learning mathematics. Sometimes the instructor might lecture, encourage cooperative problem-solving activities, or help summarize and/or generalize some of the ideas that were considered during the class. The aim is to model effective teaching that promotes mastery of both mathematics content and pedagogy. As parents of New York City public school children or as graduates of inner city schools, MAT 114 students are (re)constructing course content in unique ways that reflect increasing understanding of both content and pedagogy.

**Collaborating with Four-Year Institutions in Their Teacher Preparation Efforts**

The three former pre-college level educators who teach MAT 114 are actively involved in many organizations advocating the reform of school mathematics and programs for prospective teachers. One such group, the NSF-funded New York Collaborative for Excellence in Teacher Preparation in Mathematics, Science and Technology, meets regularly each semester and promotes articulation of mathematics and science courses offered by two-year and four-year colleges. Among the institutions included in the collaborative are New York University (NYU) and five four-year colleges of the City University of New York (CUNY). Because syllabi, such as those from NYU (E12.002, Mathematics for Decision Making), City College-CUNY (Math 185, Basic Ideas in Mathematics), College of Staten Island-CUNY (Math/SLS 118 Sections 6912/6913, Fundamentals of Mathematics I), Hunter College-CUNY (MAT 104, Math for Elementary School Teachers, Semester I) and BMCC (MAT 114, Math for Elementary Education I) are shared and discussed during meetings of the collaborative, activities and ideas are adopted by both the two-year and four-year colleges, thus promoting higher and more uniform standards of excellence in teacher preparation.

Students who successfully complete the MAT 114 course currently offered at Borough of Manhattan Community College may go on to the next level course if they pursue further study as elementary education majors at Hunter College. Due to changes in mathematics courses offered by four-year institutions that BMCC students eventually attend, MAT 114 has undergone gradual modifications. Initial changes were made to preserve articulation with Hunter's new MAT 104, the first in a neoteric series of three courses taught by both mathematics and education faculty. MAT 104 begins with the integration of probability and
statistics with mathematical pedagogy; this mathematical content is from a course that few of BMCC's graduating ECE students ever take, MAT 115. As other four-year colleges (re)designed their courses to include the pedagogy with varying combinations of the content from MAT 114 and MAT 115, it is now proposed that both courses be required so that BMCC's ECE graduates will be adequately prepared for mathematics courses at any of the four-year institutions.

Further articulation efforts are underway for a new course in Mathematical Reasoning at City College. One member of the City College Mathematics Department and one member of the BMCC Mathematics Department are involved in the development of this course.

Clearly BMCC has benefited from active membership in the New York Collaborative for Excellence in Teacher Preparation in Mathematics, Science and Technology. There is an urgent need for more two-year colleges to participate in such collaboratives to ensure that two-year college students are adequately prepared for four-year college education programs, particularly for courses in mathematics, science and technology.

As each state in the United States aims to revitalize schools to meet 21st century demands, it has become apparent that success depends fundamentally on teachers. Good teachers produce good students. Underprepared teachers of disadvantaged students are less likely to know how children grow, learn, and develop, or about what to do if children are having academic or personal difficulties. Yet statistics indicate that over 50,000 teachers annually have been entering teaching on emergency or temporary certificates with little or no preparation at all [4]. Most of the inexperienced and uncertified teachers in the state of New York are teaching in New York City schools where minority groups constitute a majority of the student population [5].

Many ECE students have attended these schools and been taught by such teachers. Inadequately prepared for college work, these students require remedial classes in reading, writing and/or mathematics before beginning their credit-bearing courses. Some ECE students must complete extensive work in arithmetic and algebra before enrolling in MAT 114. Not surprisingly, the anathema of early educational inequities can lead to even greater challenges in meeting new and more rigorous standards of CUNY teacher preparation programs and New York State Teacher Certification [5].
Poorly prepared teachers promote inequality in opportunities for students to learn and eventually achieve their academic and career goals. This can lead to educational, economic and social stagnation at the very time when all students need to be prepared more effectively for advancement in the highly-technological, global society of the 21st century. Many of BMCC's ECE students have overcome the odds cast against them by underprepared teachers. These students have begun a positive movement that gains momentum through their adequate preparation during the first two years of college for future undergraduate courses. Collaborative efforts of two-year and four-year institutions thus feed the momentum of this positive movement.

National and international assessments, such as the Third International Mathematics and Science Study (TIMSS) [6], indicate that few students are prepared to do the kinds of thinking and problem solving required for college level work in mathematics, science, reading, and writing. Students in the United States score near the bottom of most international comparisons in mathematics and science, especially on such tasks requiring critical thinking and problem-solving skills [6]. Clearly the need for good teachers, particularly those qualified to teach mathematics and science, is crucial. More precisely, the need for such teachers— that BMCC students can become in New York's inner city schools—is paramount.

Focusing on the Active Recruitment of Prospective Teachers from Underrepresented Populations

Because 65% of the BMCC student population are female and 91% are non-white, the majority of the college population is from traditionally underrepresented populations. Statistical analyses of BMCC also show that over 1,000 students are enrolled in the Early Childhood Education Program; each year, approximately 300 new students select this area of concentration in which the dropout rate is less than 14% [7].

During the next two decades the demand for teachers has been predicted to increase substantially due to higher birth rates and immigration. The teaching force has also aged considerably so large numbers of retiring teachers will have to be replaced. In New York City alone, where over fifty percent of the population will be foreign- or Puerto Rican-born, the predicted shortage of public school teachers due to retirements is estimated at 15,000 by the year 2000 [8].
Clearly, teacher preparation is crucial at this time. Statistics indicate that although the demand for new teachers is growing, the supply of newly-prepared teachers dropped sharply for two decades (1970-1989), and is just beginning to increase once again. There was a particularly sharp decline in the number of academically able minorities and women, who shifted from education to business, health professions, law, and other occupations. As these other professions opened up to minorities and women, teaching lost preference. Teaching is now forced to compete with other occupations for talented entrants [1].

Attractions to teaching have improved somewhat because higher salaries are closing the gap between teaching and other occupations. This has also helped increase teacher supply and quality. Obviously, teaching vacancies are being, and will continue to be, filled from other sources. However, attracting and retaining qualified teachers at higher rates will be vital to improving the quality of education, particularly in inner city schools. Reports of the National Center for Education Statistics show that schools with higher minority enrollments have the most difficulty filling vacancies with qualified teachers [9]. To deal with these shortages, principals sometimes hire less qualified teachers, use substitutes, cancel courses, raise class sizes, or ask teachers to teach outside their field of preparation.

Clearly, efforts to raise standardized test scores and graduation requirements in mathematics will be futile if there are not enough teachers prepared to teach the subject well. Students' critical and analytical thinking skills cannot improve significantly without teachers who know how to promote such thinking and without an environment that supports such thinking. Needs of inner-city children plagued by academic, social and economic problems detrimental to their educational progress cannot be addressed without well-trained teachers. Such teachers understand how to meet the diverse needs of students with varying learning styles, family situations, and expectations about themselves and the education they attain. Inner city students are also often in dire need of role models and mentors capable of extending guidance and support to sustain these students in the world beyond the classroom. Strengthening teaching thus necessitates stronger preparation, selection and inclusion practices.

Current educational reformers echo past criticisms that schools provide most children with an education that is too rigid, too passive, and too rote-oriented to produce learners with
higher-order thinking skills. The history of U.S. education verifies that contemporary reforms, such as the child-centered approach focusing on the needs and aptitudes of students, the thinking curriculum aimed at higher order performances and cognitive skills, team teaching, cooperative learning, student-centered instruction, and authentic assessment, actually originated in earlier decades [10]. These efforts, aimed to promote quality, equality, access and equity in education, were defeated because qualified teacher recruits could not be trained in sufficient numbers [11].

In the past, learner-centered education tended to give way to influences that lowered curriculum standards; the cycle began again when renewed criticisms of schools engendered more attempts to restructure them. Research indicates that current efforts at school reform are likely to succeed to the extent that they are built on a strong foundation of teaching knowledge and are sustained by a commitment to structural rather than merely symbolic change [12]. Major changes in the productivity of all American schools, particularly those in inner cities, are thus likely to depend on our ability to create and sustain a highly-prepared teaching force including teachers from underrepresented populations – qualified teachers for all, not just some, of our children.

References


CLASSROOM TEACHERS’ USE OF RESEARCH TO EFFECT CHANGE IN PRE-SERVICE ELEMENTARY TEACHERS

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Introduction

Activities based on mathematics education research are incorporated into a preservice content course designed to reflect the course objectives of (i) broadening and deepening preservice teachers’ understanding of the complexities of teaching and learning, (ii) encouraging them to develop reflective practices, and (iii) exposing them to the scholarship of teaching. Research articles and videos are used throughout the semester to generate cognitive dissonance that facilitates the reconstruction of inappropriately formed concept images and as sources of classroom investigations and assessment questions. The activities provide pre-service elementary teachers with experiences which result in changes in their attitudes about mathematics and engage them in professional practices that inform their instructional, pedagogical, and theoretical perspectives.

Research-based activities include a seminar experience which serves to inform students about some of the issues involved in the teaching and learning of mathematics. Assigned problems such as the Towers Problem, generate discussions that reveal students’ thinking, their understanding of proof, their beliefs about the elementary school mathematics content they need to know, and their assumptions about grade school children’s mathematical abilities. Ann’s Fraction Cookie is an activity which models the use of questions as a constructivist instructional practice and introduces the student to problems involving part/whole and part/part relationships in the absence of rote symbolic manipulations, with the goal of developing conceptual understanding of these relationships. These activities and their impact on students are described in this report.

The Seminar

The seminar introduces students to mathematics education research and the scholarship of teaching. In preparation for the seminar, students are given a handout describing a seminar:
A seminar brings together an interested group of learners who have done some preparation outside of class, including having read, thought about and written about various research reports and articles. Seminar is a time to "mine" the research, to work it over as a group, to think aloud about it, and to test your ideas against those of other members of the group. It is a special time for a unique intellectual activity — the exchange of ideas focused on a source (research articles, a book, a video, etc.)

A second handout with suggestions for writing an effective and useful seminar paper, together with a list of focus questions directed at salient features of the assigned readings is also distributed. Attendance at seminar is mandatory.

Students are given copies of three or four research articles, which they are assigned to read in preparation for the seminar. Sources of these seminar readings include various mathematics education research journals, papers presented at conferences, and/or books which include various researchers' writings on specific topics/issues of mathematics education. A short list of questions designed to focus students’ attention on some of the salient features of the assigned readings is distributed along with the readings. Students are requested to note text passages they find most interesting and to review the articles in light of the focus questions with which they have been supplied. Each student writes a short paper (3-5 pages typewritten) in which the research articles are analyzed and the relevance of the research to the student’s own previous mathematics experiences is described. Students report to seminar with their written question(s) about some feature of the readings they would like clarified and at least one notion they found particularly interesting/relevant that they are prepared to discuss. The questions and the particular ideas or topics of interest, together with the students’ seminar papers, form the basis for discussion during the seminar.

Prior to the seminar, students review the individual and group responsibilities described in the seminar handout. They are responsible for conducting the seminar and directing the discussion. The instructor’s role in seminar is that of an observer and occasional participant as s/he moves from group to group and room to room, neither the focus of attention nor the authority who tells students what they should learn. In order to provide greater opportunity for all students to actively participate in the discussions, participants form small groups (5-6 students). Seminar discussions take place in two adjacent classrooms, three groups per classroom. A follow-up discussion at the next class meeting provides opportunities for students from the various groups to share their seminar experiences with other members of the class.
and students submit their written papers for evaluation.

Reactions to the seminar experience, based on the seminar discussions and their written papers, suggest that most preservice teachers re-examine their own mathematics learning as a result of their engagement in this reflective activity. The following excerpt from a student’s seminar paper is typical of the comments:

When I read these articles, I began to think about my own math education. I thought back to when I was in first grade and in high school. I would have to say I used instrumental understanding all the way through. That is the way I was taught. In first grade, I was taught to count the points on the numbers, but when I got to $9 + 9$, there were no points, so I couldn’t solve the problem. In high school, when we were using algebraic equations, I never knew why. I never knew why, if you used a certain equation, you would come up with this answer. We were always given an equation, showed how to apply it to a number and that was it. No explanations of why it worked the way it did.

This student’s written description and her subsequent comments during the seminar and in the follow-up session, suggest that she has a conceptual orientation, i.e., she feels a need to know why something works as well as how it works. It seems that her prior remembered experiences occurred in a classroom in which the instructor provided only a calculational orientation [1]. These prior experiences left her with feelings of frustration and a distaste for mathematics. The assigned readings and seminar activities provided a validation of her expectations that mathematics should make sense and gave the student a renewed confidence which was evident throughout the semester.

Classroom and Journal Investigations

Research articles are a rich source of problems which provide documentation of students’ thinking and beliefs. Two such problems featured in research reports, Building Towers and Ann’s Fraction Cookie, are described, along with their use in the preservice course.

Building Towers [2]: Pre-video Experiences

Early in the semester, preservice teachers are assigned the problem, Building Towers, as homework:

Given plastic cubes of two different colors (red and blue):

a) Build as many different towers as possible four cubes high without omitting or
duplicating any.

b) Convince other members of your group that you have built all possible different towers and that you do not have any duplicates.

During the next class meeting, students discuss their work and solution(s) to the problem with other members of their group, justifying their results. Members of different groups then share their discussions, solutions, methods of investigation, and justifications. The groups then explore Building Towers II:

Given plastic cubes in two different colors (red and blue):

a) Build as many different towers as possible five cubes high without omitting or duplicating any.

b) Convince other members of your group that you have built all possible different towers and that you do not have any duplicates.

Preservice teachers' initial explorations of this problem generate classroom discussions that reveal their thinking about the problem. It is a problem characterized as easily accessible—that is, every student is able to get started on the problem and work out a solution, though the solutions of many preservice teachers are frequently incorrect. After the class investigations and further discussion, students are assigned a reflection journal as homework and asked to complete the following:

I first thought....
I first attempted the problem by....
After talking with my group I realized....
I know I have all the towers because....

These written reflections reflect the range of abilities and ways of thinking of different students. A typical response was:

When I first looked at this problem I thought it was going to be very complex and difficult. I don’t know if I have all the answers...Every time I think I have all the towers I find a couple more. It’s driving me mad!!! I know there is a pattern but I’m not sure what it is....However, I just realized that some towers repeated, so this pattern really doesn’t work. Augh!!!

Occasionally, some students indicate they have made connections with previous problems which they recognize as having a similar structure. A student recently wrote:
I first thought that this problem might be like the ice cream problem that we did from the book. We were dealing with 4 elements (cubes) in the tower problem and 4 toppings in the ice cream problem. I first approached the problem by reviewing the ice cream problem. I remembered that there were 16 different combinations of toppings in the ice cream problem. I also remembered the following table from our text:

<table>
<thead>
<tr>
<th>Number of Elements</th>
<th>Number of Subsets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>32</td>
</tr>
</tbody>
</table>

This student went on to complete the statement: *I know I have all the towers because...*

This helped me generalize about a tower with \( n \) numbers of blocks. For any set with \( n \) elements, the number of subsets (combinations in this case) of that set is \( 2^n \). This helped me verify that there would indeed be 16 different towers of 4 cubes and with 5 cubes we would get \( 2^5 \) which is 32 combinations.

In general, preservice teachers' understandings of the nature of proof provide little cause for rejoicing by their instructors. Few students are able to provide a valid proof. They generally fail to recognize that the fourth-graders use various methods of proof to justify their work, including proof by exhaustion and proof by induction. More representative of the responses to the question of whether they have found all the cubes is the statement:

*I know I have all the towers because I have talked with the people in my group and we all had the same answer.*

Some students, perhaps not quite convinced that their group members are correct, look to other groups for verification:

*We have also talked to other classmates and have all come to an agreement. Therefore we have all possible towers.*

Unfortunately, they don't. In a recent class, twelve of the twenty-three students did *not* find
all possible four- and five-cube towers. The approximate percentage of 50% of students who find a correct solution has remained fairly consistent during the four years we have used the problem.

Building Towers I and II: Post-video Reflections

Following the preservice students’ investigations of the Towers problem, a twelve-minute video of a group of four fourth-graders working on the same problem is viewed by the class. (The videotape is part of a longitudinal research study on the nature of elementary grade children’s experiences with proof.) The videotape presentation generates discussion in which students’ beliefs are revealed about elementary school mathematics content they need to know and their assumptions about grade school children’s mathematical abilities. Students are assigned to write a second journal in which they are asked describe their observations about the four fourth graders on the video clip, together with reflections on their own investigations of the Towers problem. They were asked to answer four questions:

As a result of class discussion, I now realize about the Tower Problem....
Before seeing the video of the 4th graders doing the Tower Problem, I thought that....
After seeing the video, I now....
I have the following additional comments and/or reflections....

Several students were surprised to discover the variety of ways the problem could be approached, an observation typical of a majority of students after viewing the video. Many of the preservice teachers commented that, prior to watching the video, they believed “the fourth graders would have a harder time dealing with the problem than they did.” Several preservice teachers acknowledged that fourth grade students did better than they (the preservice teachers) had done and that the elementary grade students were more capable of doing a higher level of mathematics than previously thought. Typical comments were:

After seeing the video, I realize just how intelligent 4th graders are. They seem to be so willing to explore different ways about finding solutions.

Children are doing more difficult tasks at a younger age than I was.

I realized that 4th graders can handle this concept and with ease! I felt a bit ‘challenged’ by the intelligence and confidence the 4th graders displayed.
A few students, after viewing the video, saw connections to other problems they had missed in their previous investigations:

The pattern was Pascal's triangle, and those kids were a heck of a lot smarter than I thought. Their ideas and thoughts were very advanced.

The reflections and subsequent class discussions form the basis for later investigations into the nature and role of proofs, including an analysis of the proofs given by the fourth graders in the video clip.

**Ann's Fraction Cookie [3]**

Preservice teachers generally have little conceptual understanding of fractions and have learned operational algorithms by rote. Less than fifteen percent of preservice teachers each semester have been able to demonstrate mastery (85% correct) on a thirty question competency test of basic arithmetic skills given during the first week of class. The areas of greatest difficulty for these students are the questions which test basic skills with fractions and those dealing with proportional reasoning. A common strategy for finding the sum $9 + \frac{3}{8}$ is to change both addends to improper fractions, combine the terms, and attempt to convert the answer to a mixed number. More than seventy percent of the students who have enrolled in the preservice content course during the past six years used this strategy.

Experiencing cognitive dissonance can be effective in the restructuring of previously-acquired inappropriate concept images. The following activity has been effective in generating cognitive dissonance which resulted in students' restructuring of their existing schemas. Ann's fraction cookie activity is designed to provide students with experiences of part/whole and part/part relationships. Students are given the "cookie" and asked the following series of questions:
The Questions

1. A is what part of the whole cookie?
2. B is what part of the whole cookie?
3. How did you figure out your answer?
4. C is what part of the whole cookie? Why?
5. Can you show me half of the cookie?
6. Can you see any more halves?
7. How many ways can you make one-half?
8. What is more important, the shape or the number of squares?
9. How many ninths would make half of the cookie?
10. How many ninths would make the whole figure?
11. How did you figure that out?
12. If I give you forty-five ninths of this cookie, how many cookies would you be able to make?
13. Suppose I give you one thirty-sixth and one eighteenth of a cookie. What part of the cookie have I given you? Why?
14. Suppose I give you two thirty-sixths and three eighteenths, what part of the cookie would you have? Why?
15. What part of the cookie would you have if I give you three ninths and two eighteenths of it?
16. Instead, suppose I give you one sixth and one ninth of the cookie, what part of the cookie would you have?
17. If I give you two sixths of the cookie and then three ninths of the cookie, what part of the cookie would you have? Why?
18. Suppose I have a certain amount of money. I would like to give you one fourth and one eighth of that money. What part of my money would I have given you?

The responses to these questions are based on understanding the relationships among the
various components of the fraction cookie manipulative. Students are not permitted to use pencil and paper to calculate their responses, only to record their answers to this series of questions. For homework, they are to read the research article that reports Ann’s investigations based on the same questions. Additionally, the preservice teachers are to identify the fraction operations in the questions used during the initial class investigation. They are to note the sequence in which the operations were introduced. Students are given a second copy of the cookie, which they use as manipulatives to continue their explorations of the various relationships.

The investigations utilizing the Fraction Cookie manipulatives introduce a sequence of activities leading to discussion of "What’s my unit?" and a more conceptual understanding of the operational algorithms students have learned previously. This problem introduces students to the use of manipulatives. Students’ final course interview comments typically mention their reaction to the introduction and use of manipulatives:

Instead of thinking I have a math disability of some kind, I am starting to think of math as a journey into more exciting learning experiences. I had so much fun with the fraction manipulatives, I went and bought some; my husband laughs at me because I like to do problems with them during the commercials on tv.

Assessment and Evaluation Activities

Research articles are also a source of problems used as evaluation items on small group take home exams and on small group oral exams. Preparation for the small group oral exam offers students opportunities to demonstrate the creativity inherent in mathematical thinking in ways most of these students have not experienced previously. Two problems that have been extremely effective in revealing how creatively students think about a problem are Sam’s Cookies and The Bowl and Measuring Cup [4]. Both problems afford students opportunities to demonstrate their ability to use manipulatives effectively and appropriately—opportunities which allow students to use their imagination in wonderfully creative ways.

Sam’s Cookies

Sam has 35 cups of flour. He makes cookies that require 3/8 of a cup each. If he makes as many such cookies as he has flour for, how much flour will be left over?

The manipulatives that students use to demonstrate their solutions to these problems have
included hand-made manipulatives as well as "found" manipulatives. One group used Legos to demonstrate their solution to Sam's Cookies. They arranged thirty-five 8-cell units, forming a base layer representing the thirty-five cups of flour on a flat Lego platform. On top of the thirty-five 8-cell units, they placed 3-cell units, arranged to cover as much of the 35 8-cell units as possible.

The Bowl and the Measuring Cup

Perhaps the problem that students have the most fun with is The Bowl and the Measuring Cup:

You are given a large bowl and a small measuring cup. As quantities to measure, you have some rather large pebbles and some fine-grained sand. You repeatedly fill the measuring cup with the pebbles, transferring them to the large bowl until it is filled. By counting you have determined that it required 27 cups of pebbles to fill the bowl. You then empty the bowl.

a) Calculate how many cups of sand will be needed to fill the bowl to the top.

b) Put 20 cups of pebbles into the empty bowl and calculate how many cups of sand will be needed to fill the bowl to the top. Consider what arithmetic operation is appropriate for this situation, if any. Once you have made your choice, carry out the appropriate calculation (you may use a hand-held calculator), then verify your answer.

c) Describe the essential mathematical tasks contained in this problem.

Each semester, one or more groups attempt to replicate the problem conditions as precisely as they can. One group, working at a member's home, crept out during a rainstorm and "borrowed" pebbles from the neighbor's driveway across the street and sand from the next-door neighbor child's sandbox. Another group, not certain a cup was a cup was a cup, used every bowl in the house, then borrowed additional bowls from the neighbors as they investigated the problem, using cereal and sugar; hard candy and salt; and other combinations of materials—they couldn't find any pebbles or sand, nor could they find a bowl. Another group spent a week locating "proper equipment" before attempting to solve it—they measured how much liquid every bowl in each of their four houses could hold, trying to find a bowl that held exactly twenty-seven cups.

The adventures that preservice teachers have investigating this problem are described by
the student who wrote on her final portfolio evaluation:

We solved many word problems over the semester (and I think that math learning should be mostly word problems), but my favorite had to be the problem on the oral exam concerning the large bowl, the measuring cup, the sand, and the pebbles. The sand, pebbles and bowl problem asked us to make a prediction about the ratio of the sand to the pebbles. This led to a long discussion about whether “a cup is a cup” no matter what is inside. This lively debate caused our group to rethink preconceptions about this idea, and to perform tests to prove or disprove our various hypotheses. What made it most enjoyable was all the time that our orals group spent arguing about it, and the fact that we were pouring fish rocks in the Denny’s Restaurant for hours. We argued, we laughed, and we griped, but we all learned from sharing one another’s ideas and methods. It was a rich experience that I’ll not soon forget.

Her change in attitudes and beliefs during the semester is clearly demonstrated if one compares the portfolio evaluation comments with comments written during the first week of the semester in her autobiography. At the beginning of the semester, this student wrote:

If you have the words ‘Beth’, ‘math’, and ‘highlights’ in one sentence, there must be an oxymoron in there somewhere. Although I don’t feel that I’m afraid of math as much as I’m just frustrated with it, I must be one of those students who suffers from math anxiety.

Summary

Students’ lack of conceptual understanding of foundational mathematical ideas—their inability to interpret and use ambiguous mathematical notation effectively and appropriately; the plethora of misconceptions and inappropriate concept images they enter class with; their innate and learned over-reliance on rote procedures and inflexible schemas; together with their negative attitudes and beliefs about mathematics are some of the issues that confront the instructor of preservice students. The responses cited in this paper illustrate the lack of prerequisite mathematical knowledge and skills preservice students bring to our courses. College students who cannot add two mixed numbers correctly; who are convinced they need to change a whole number to an improper fraction before adding to a mixed number; who believe that fourth graders know more mathematics and can solve problems more easily than they can—these are the students who hope to teach mathematics to the future generations of students.

How do we narrow the gap between the under-preparedness of preservice students and the
level of conceptual understanding and competence necessary to teach future generations of students? Given their lack of mathematical competence and conceptual understanding, the accomplishment of many of our students in the short period of a sixteen week semester are quite remarkable. But is it enough? A growing body of research [5] suggests that instruction designed with a reconceptualized view of mathematics and learning can improve students’ competency and understanding of what mathematics is, what it means to know mathematics, and how to go about learning mathematics. The literature provides a framework within which to interpret our observations and student work, and is a rich source of problems which reveal students’ thinking. A student’s self-assessment upon completing the preservice content course summarizes the impact research-based activities had on her beliefs and attitudes:

Upon entering this class, I was really stuck in a rut—if it’s math, I can’t do it...Mathematics almost seems a philosophy to me at this point. I am taking an astronomy course in conjunction with this class, and the discovery in both classes of the appearance of patterns as a problem-solving tool has really solidified this technique for me. I see math as a tool that is there to work for me rather than something to make things more difficult.

Students’ responses such as this, together with the improvements in mathematical competence and understandings they have demonstrated, suggest that activities and evaluations grounded in research can play a vital role in the development of future teachers. More work on effective uses of the research literature is needed. We invite you, the reader, to join with us as we continue to explore ways to incorporate research findings into our instructional practices.

References


THE INTEGRAL ROLE OF TULSA COMMUNITY COLLEGE IN THE MATHEMATICS AND SCIENCE PREPARATION OF PROSPECTIVE TEACHERS

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The role of the two-year college in the mathematics and science preparation of prospective teachers is fast becoming a prominent influence on teacher education programs across the country. This article describes the multifaceted role of Tulsa Community College (TCC), Tulsa, Oklahoma, in the preparation of prospective teachers in math and science. Since 1987 Tulsa Community College has hosted many events, activities, and programs aimed at the sciences. TCC activities/programs have focused on five areas:

1. preservice and inservice preparation;
2. summer teacher institutes supported by state and federal grants;
3. recruitment and emphasis on underrepresented groups;
4. parateacher associate degree/certification program;
5. workshops, seminars, and other activities.

This article presents the TCC role by examining these five areas in terms of assessment of successful strategies, significant collaborations, and impact of the TCC teacher preparation activities on students and the community. Also presented are the implications for future TCC programs and the TCC vision for the math and science preparation of prospective teachers for the 21st century and beyond.

If the United States is to become first in the world in mathematics and science by the year 2000, the high quality preparation of K-12 math and science teachers is a critical requirement and must involve educational institutions at all levels. Even before the NCTM Standards [1] and Everybody Counts [2] in 1989, before the Presidential Goals for the year 2000 [3] were adopted, before the AMATYC Crossroads [4] was generated in 1995, and before the results of the National Assessment of Educational Progress (NAEP) indicated the paramount need for the quality preparation of teachers in mathematics and the sciences [5], Tulsa Community College, was continuously involved in programs and activities to recruit and prepare educators into mathematics and science education. Since 1987, Tulsa Community College has hosted a myriad of events, activities, and programs aimed at the recruitment and preparation of preservice and inservice preK-college math and science teachers as well as the math and science preparation of prospective teachers in all disciplines.

The multi-faceted role of Tulsa Community College in the science and mathematics preparation of prospective teachers is presented here in terms of program descriptions,
assessment, impact on students and the community, successful strategies and significant collaborations, and implications for future TCC programs and offerings.

Description of Activities

Five areas of focus exemplify the high quality efforts employed by Tulsa Community College over the past ten years relative to the field of math and science education:

1. **Preservice and Inservice Preparation:** The TCC SPICE (Special Preservice and Inservice Courses for Educators) Program begun in 1987 consists of college credit courses offered each semester in compressed, intensive, compact time periods that focus on specific interests and needs for teacher preparation and conform to the schedules of both inservice and preservice educators. Although the SPICE Program encompasses all disciplines/subject areas for educators in the preK-college grades, the inception and yearly focus of the program has always been in the areas of math and science education, because of the indicated need for community, state, and national assistance in these areas. Since Oklahoma has been identified as below the 50th percentile in both math and science achievement on most national polls, the need for the SPICE Program to accept these two areas has been paramount. A few examples of some SPICE courses that have been successful include: Using Manipulatives in Algebra Classrooms, Hands-On Aerospace for Teachers, Metric Madness for Teachers, Math in Children’s Literature, HIV Peer Education for Teachers, Exploring Geology of Oklahoma for Educators, and Multicultural Math/Science for Teachers. Enrollment in TCC SPICE courses approximates 2000 per year with about 60% preservice educators and 40% inservice teachers. One huge success of the SPICE Program has been the mixing of veteran teachers with undergraduate education majors in hands-on classes that have fostered mentoring, idea exchanges, career advisement, and many other indirect benefits. In 1995, the TCC SPICE Program partnered with Rogers University in Tulsa to create the SPICE-Plus Program which has been offering graduate education courses for the past two years. This connection has enabled the community college students to easily transfer SPICE courses to any four-year institution in Oklahoma.

2. **Summer Teacher Institutes supported by State and Federal Grants:** Since 1995 TCC has been selected as the recipient of funds for Eisenhower/NSF grants to host summer institutes for K-12 teachers in the areas of math and science education. These include: “1995
Using M. & M.'s (Manipulatives and Multimedia) in Middle School Mathematics," a four-week summer institute for 20 math teachers grade 5 to 9 with Jenks Public Schools in partnership; "1996 Tulsa Math Equity Summer Teacher Institute," a two-week summer institute for 40 math/science teachers in partnership with Phillips Petroleum Company and Union Public Schools, and “1998 TEEMS: Teams Enhancing Eisenhower Math and Science Projects,” a collaborative six-week institute with four school districts and four colleges across Oklahoma. Support for these activities was provided under the Eisenhower program, Phillips Petroleum, and the National Science Foundation.

3. Recruitment and Emphasis on Underrepresented Groups: The TCC Student Education Association was formed in 1994 to encourage community college students to become involved in activities associated with teaching, especially in the areas of math and science. This first focus of the TCC SEA was to begin an intensive math/science mentoring program at Monroe Middle School (adopted by TCC) which had been listed for five consecutive years on the “at risk” list. In addition, the TCC SEA has hosted staff development programs for the Monroe teachers, conducted tours of the math and science labs in Tulsa area schools, hosted speakers for parent and teacher groups in the community, visited Phillips Petroleum Company, Westinghouse, and Ford Glass plants for examining engineering and equity practices in math and science, have attended Oklahoma Math and Science Teacher Conferences, and have participated in many other events and activities that directly relate to math/science education. In 1997, the TCC SEA was awarded $4000 in Future Teacher Scholars Scholarship tuition fee waivers to be awarded to undergraduate math or science education majors. Eight SEA students were awarded $500 each.

4. Parateacher Associate Degree/Certification Program: In 1996 TCC was selected to participate as the only two-year school in Oklahoma (with five four-year institutions) in the Oklahoma Teacher Collaborative to encourage the preparation of math/science teachers that is funded under the NSF Collaboratives for Excellence in Preparation of Teachers to develop a curriculum and degree program for certifying parateachers (formerly known as teachers aides) in a two-year associate degree/certification plan specifically in the areas of math and science. The grant provides incentive tuition fee waivers for students interested in pursuing a parateacher associate degree/certificate in the areas of math or science. To date, approximately 40 students are currently enrolled in the TCC math/science parateacher
5. **Workshops/Seminars/Conferences/and Other Activities:** In addition to hosting the Oklahoma/Tulsa Councils of Mathematics Teachers and Science Teachers Associations annual meetings since 1985, TCC has supported the following projects: Mind Over Math Seminar (1985-over 300 parents and teachers); Hands-On Science/Math Workshop for Tulsa Catholic Diocese Teachers (1986-over 100 teachers); Robotics for the Classroom (1987-over 200 teachers); Math Counts Competition and Teacher Coaching Preparation (annually since 1993-over 500 teachers); Implementing the NCTM Standards Workshop (annually since 1989-over 500 parents and teachers); Math and Science Summer Academies for High School Students (annually since 1990-over 600 students); Math Manipulatives/Technology/Science Laboratories Workshops (annually since 1987-over 1000 teachers); and many college programs for children, adolescents, and parents featuring non-credit courses focusing on math and science education since 1985. Also, TCC has fully equipped its mathematics and science laboratories with the materials and technology needed for teaching math and science college courses per the *Standards* [1] and reform strategies.

**Assessment and Impact**

Current assessment practices of the TCC five areas of focus for the math and science preparation of prospective teachers include faculty/course/program evaluations, enrollment/student participation patterns, community involvement, and the identification of successful strategies and significant collaborations. Results of these assessment procedures indicate highly rated effectiveness for faculty and course offerings and high quality programs in all five of the focus areas. Enrollment and student participation patterns reveal continuous increases in growth. The strong positive impact of the TCC activities on students and the community is evidenced by the substantially consistent support demonstrated by student interest, enrollment, and participation, and by the active commitment of the community to the college's marketing and support activities.

Demonstrated examples of community support are the numerous significant collaborations that have evolved connecting the TCC math/science education activities with the educational communities across Oklahoma. These include: (a) endorsement/marketing assistance for TCC from virtually all public and private school districts across the state and including the
Oklahoma State Department of Education; (b) collaborative authoring with TCC of state and federal grant proposals with various universities, businesses, and school districts; (c) connecting TCC degree programs with various state/private universities’ teacher education programs; and (d) the development of an advisory professional development committee of regional schools/colleges/universities for supplying direction and assistance for TCC activities. Many of the successful strategies of the TCC exemplary activities identified by the assessment procedures have been a product of these significant collaboratives.

One powerful exemplary strategy identified by TCC students and the educational community focuses on the way in which the activities/courses/programs are created from the expressed needs of the educational community rather than the college dictating the offerings. In addition, TCC activities, courses, programs are flexible and change consistently in content to reflect the reform and issues concerns of math and science education preparation for prospective teachers. Flexible scheduling of course offerings to appropriately meet the needs of the adult college student, such as weekends, evenings, and mini-concentrated time periods to accommodate work and family schedules is also a priority.

An overall assessment of the TCC exemplary activities to date reveals high quality preservice opportunities in the math and science preparation of prospective educators.

Future Implications

Implications of the five focus areas of TCC exemplary activities for the future preparation teachers in math and science involves the college’s vision regarding technology for the 21st century and beyond. Plans are currently underway for the construction of the Tulsa Area Professional Development Center, to be housed and co-directed by Tulsa Community College and the area school collaboratives, focusing on the math, science, and technology preparation of preservice and inservice educators. Also, the creation of an information network/list-serve operation center at TCC for electronically keeping students and the educational community updated and informed of the latest news and issues in their field is planned for the near future.

The TCC vision for the future includes a solid commitment to the improvement of math and science education. This presentation provides only a sketch of the total picture and total vision embraced by TCC for the future. TCC stands committed to providing high quality
programs and activities for the encouragement, recruitment, preparation, retention and empowerment of teachers in math and science education. TCC remains steadfast in the implementation of the Standards in math and science, especially in the focus area of equity. Providing excellence in teaching and in math and science education for all students regardless of age, gender, ethnicity, ability level or disability/handicap, geographic or socioeconomic background, or philosophical/religious background is a primary goal for Tulsa Community College for the 21st century and beyond.

References


Collaboration, creativity, communication and change. These four words describe the foundation for reform efforts in mathematics and science nationwide. These words also describe the foundation for reform in preservice teacher education programs in the state of Delaware.

Collaboration
Several years ago, faculty from three branches of postsecondary education, Delaware Technical and Community College (DTCC), the University of Delaware (UD), and Delaware State University (DSU), banded together to discuss the need for reform in the mathematics and science preparation of elementary and middle school teachers graduating from their respective colleges. It was generally agreed that the mathematics and science course work required for preservice teachers was insufficient in terms of credit hours, organization, and alignment with reform standards for teacher preparation.

One often hears of the chasms dividing two-year and four-year colleges, their difference in student bodies, faculty attitudes, and opinions. In our situation, working with volunteers from DTCC, UD, and DSU interested in reform, we found a delightful group of hard working, creative, and like-minded individuals. Eventually application for funding for proposed initiatives was made to the National Science Foundation and funding was granted (DISCUS: Delaware’s Innovative Science/Math Collaboration for Undergraduate Success). At the community college level the money NSF provided allowed our collaborative group to participate in training activities and to purchase materials and manipulatives for our new courses (Mathematics for Elementary Teachers I and II). The DISCUS initiative at the three schools supported substantial reform or revision of 15 courses.

The Mathematics for Elementary Teachers courses at Delaware Technical and
Community College were written upon the foundations of the NCTM and AMATYC mathematical standards. These courses include alternative methods of assessment, team teaching, group learning projects and hands-on activities that give students experience with manipulatives as they receive instruction in topics that include probability, geometry, statistics and technology. These courses have been articulated with four year institutions within the state.

One of the mechanisms for change was the introduction of "Big Projects" to a total of eight courses in areas of biology (UD), chemistry (DTCC), and physical science (DSU and UD). The courses which use Big Projects are rather varied. "Quarks, Gluons, and the Big Bang" at the University of Delaware is a course on particle physics addressed to general audiences—students who are not specializing in science. Students are given data on elementary particles and are asked to discover the underlying symmetries. They analyze results and "publish papers" for other students in the class electronically. The other UD astronomy course, "Earth in Space", which uses Big Projects is a summer course taught to in-service teachers. Teachers have to complete an observational or research investigation and also report on the classroom application of the astronomy they have learned in the class.

One of the biology courses which uses big projects is "Introductory Biology", a large, multi-sectioned course at UD taught in lecture by several different instructors and in laboratory by a lab coordinator and an ever-changing squadron of laboratory instructors. Students experiment with the life cycle of an organism over periods of several weeks. Experiments with Wisconsin Fast Plants, a very rapid growing strain of *Brassica rapa*, test the effects of different levels of pH, salt contamination, or amounts of fertilizer on plant growth. Collaborations between mathematics, physics, and biology faculty are exploring ways in which statistical techniques can be used to assess the results. Students in "Human Anatomy and Physiology" assess the effects of various stimulants (often caffeine) on various aspects of human physiology such as heart rate and respiration rate, using other students in the class as subjects.

Two physical science courses taken by preservice elementary school teachers have been transformed in ways that are slightly different, because the courses are different. "Physical Science and Technology" at UD resembles introductory biology in that it is a multi-
sectioned course required of all pre-service elementary teachers. A dozen or so TA’s lead the laboratories, and each year most of the TA’s are new to the course. For four weeks, students work in teams of 4-5 to design and conduct their own experimental investigation. The results are presented initially to their laboratory section, and selected teams then present the results to the campus in a poster session. The "Physical Science Survey" (27-201) course at Delaware State University is unified by a number of "great ideas" and includes several teaching strategies, including design activities which extend over several classes [1].

Other reformed courses include "Black Holes and Cosmic Evolution", (UD), a course taught by a single faculty member to a roomful of 340 students. In about 1/3 to 1/2 of the classes, students do group work. While the group work is often pencil-and-paper analyses of graphs and texts, occasionally they do mini-labs in a lecture room. This course has been extensively evaluated by a team of faculty and graduate students from the University of Delaware school of education, working with the course instructor who teaches in the physics and astronomy department. "Earth Science" at DSU is a required course for prospective teachers that includes three cooperative problems that students solve as a group as well as activities which require students to find out information on their own using the Internet. As a result of the collaboration, faculty have shared ideas and laboratory exercises, thereby encouraging and sustaining the development of student-centered, inquiry-based learning activities at all three institutions.

Creativity

As our courses developed, our enthusiasm grew and so did our imagination. Additional projects and training were developed at Delaware Tech, the University of Delaware and Delaware State concurrently. A local school district allowed three instructors from Delaware Tech to participate in in-service training activities for K-6 grade teachers. Our preservice mathematics content courses at Delaware Tech became "hands-on" and "minds-on". The students now work their way through math content in probability, statistics, geometry, measurement, algebra, and other topics while experiencing the variety of methods and assessment measures proposed by reform documents nationally. Student response to the course work at all schools has been consistently positive and unanimous in praise.

The NSF funding enabled instructors at the community college to incorporate most
of our reform concepts. The purchasing of manipulatives, books that link mathematics with literature, measuring devices, and reference documents allowed us to complete our lending library. In addition to the extensive demonstration and use of these materials in class, the materials are also checked out to education majors at Delaware Tech for use during their student teaching practicum.

National documents on reform speak to the need to incorporate technology into preservice classrooms. Research at two-year colleges indicates that while over ninety percent of preservice teacher mathematics courses incorporate calculators, less than forty-five percent incorporate computer training [2]. Students at DTCC use the Internet to search for standards-based lesson plans that are then presented as a part of their mathematics classes. Students in these preservice classes communicate with faculty through the campus e-mail system, open to all who register for classes at the college.

Communication

With the recent funding of the second phase of our state-wide collaboration (IMSTEP - Integrating Math and Science in Teacher Education Programs) we will be able to begin our community outreach program. Mini-seminars will be offered to area day care workers, Head Start staff, education majors at the area colleges, and elementary school teachers in the Wilmington area. These programs will demonstrate mathematics and science lessons for preschool and elementary school teachers in an interdisciplinary format. All after-school sessions will include mathematics and science standards and will hopefully forge a strong link between our college and the inner-city community.

The children of Delaware will ultimately benefit as the materials of reform are absorbed into classrooms statewide. Opportunities that our children will have to experience, enjoy, converse, and achieve in areas of math and science are essential for student success. We plan to provide these opportunities. Team teaching across departments at DTCC, UD and DSU will be a part of this second phase as well.

Communication standards are at the heart of the national reform effort. Mathematics anxiety is a palpable component of preservice teacher education. Students with fine preparation in mathematics seem also to carry the burden of this anxiety. It is a high priority
for faculty at DTCC to address this problem directly, and diminish students' fears through the use of a variety of instructional styles and assessment measures.

Recently, a student, Connie, was asked to share her answer to a problem in class; Connie said she believed the answer to be fourteen square centimeters. I asked Connie to explain to me how she had arrived at that answer. How sad it was to see her erasing the answer on her paper. I assured her the answer was correct and that she shouldn't be erasing an answer so nicely computed. Connie replied, "You know, I was sure my answer was wrong. Every time someone has asked me to explain my answers, it was because my answer was wrong." Clearly, past experiences in mathematics are often negative and vividly remembered by our students.

Group discovery sessions, hands-on experiences with math manipulatives, and the opportunity to defend and describe mathematical conjectures are all a part of a standards-based preservice teachers course. Students have a vast experiential base in individual isolation within mathematics classes. Discussing, supposing, writing and defending mathematical ideas is a totally new experience for most of the students we teach in our preservice teachers course. Faculty teaching these courses must nurture a spirit of inquiry and must use the same instructional techniques in their classes that the prospective teachers will be expected to use [3].

Change

What is it like to teach these future teachers? It is exhilarating, exciting and exhausting. It takes much longer to prepare these high-activity, fast moving classes than one would imagine, unless one has already taught at the elementary school level. It is also a wonderful experience and we would not have missed it for the world.

The following anecdote demonstrates the change that we have accomplished in a short time: One of the early childhood education adjunct instructors presented an activity in which he gave his methods class a pile of assorted objects (chopsticks, rubber balls, milk gallon caps, etc.). The introduction given was, "You are working at a day care and there is no budget for materials. What kind of lesson plans can you come up with using these objects?" As the students started offering idea after idea in rapid succession, the instructor wrote down their
ideas. He was amazed. "Last year," he said, "the students offered no ideas in mathematics and science. This year, you came up with seventeen. What happened?" The student response was, "Let us tell you about our new math classes!"

The proposed science course for preservice teachers at Delaware Tech will focus on three major questions: (1) What is the nature of science? (2) What is the nature of matter? (3) What can science tell us about the human body? This course is in the early stages of development but the goal is to develop student-centered, inquiry-based activities that integrate science and mathematics. The mathematics will become less abstract and the science more understandable.

In the area of preservice training, it is generally accepted that most teachers teach as they were taught [4], [5]. Assuming this to be true, it is crucial that courses taught to prospective elementary school teachers in mathematics be taught using topics and methods identified in reform documents [6]. In the preface from A Call for Change [7], the challenge is clearly stated for those who teach preservice teachers.

In order for teachers to implement the curriculum envisioned by the NCTM Standards, they must have opportunities in their collegiate courses to do mathematics, explore, analyze, construct models, collect and represent data, present arguments, and solve problems. The content of collegiate level courses must reflect the changes in emphasis and content of the emerging school curriculum and the rapidly broadening scope of mathematics itself.

Although much progress has been made, concerns still exist over the future of reform coursework. Collaboration between institutions allows for meaningful changes to be implemented. However, collaboration within and between institutions often moves at a slow pace. Resistance to change is a mighty force, perhaps the single most importance force affecting standards reform.

It has been said that the only person truly ready for change is a wet, messy, baby. Not true! America's two-year colleges are ready to start on the changes that will enable our preservice teacher population to enrich classrooms with the knowledge and enthusiasm they have gained in reform based classes.
References


In 1992, Grand Rapids Community College (GRCC) was one of six community colleges invited to participate in a NSF initiative to improve science and mathematics teaching within the state of Michigan. This initiative included all public teacher preparation institutions in the state. GRCC has responded to this challenge by:

1. designing a new course in Physical Science for future teachers;
2. creating the GRCC Teacher Education Pathway and the GRCC Teacher Education Center;
3. forming a local alliance with Grand Rapids Public Schools and Grand Valley State University for the purpose of recruiting and supporting minorities in mathematics and science teaching.

Background

In 1992, Grand Rapids Community College was one of six community colleges invited to participate in a NSF project to improve science and mathematics teaching at the state level. The Michigan Statewide Systemic Initiative (MSSI) was organized under the direction of the Michigan Department of Education. Several working groups were formulated and one, the Michigan Teacher Preparation Collaborative (MTPC), focused its energies on new teacher preparation. The MTPC soon drew representatives from every public teacher preparation institution in the state, a coalition of private colleges and a coalition representing the state's 28 community colleges. At the end of the funding cycle, community colleges were represented on the MTPC Executive Board and in all major working groups.

The three goals of MTPC are: (1) to improve the teaching and learning of science and mathematics by promoting instruction for active learning; (2) to create meaningful curricula; (3) to support equitable practice by extending opportunities for participation in science and mathematics to underrepresented groups. Statewide, colleges of education have given a close look at the kinds of experiences future math and science teachers need to be successful in the next century. New science and mathematics activities and courses have been written and shared at state conferences of the MTPC. Four local alliances have been formed uniting urban school districts with community colleges and public universities for the purpose of...
recruiting and supporting minorities in mathematics and science teaching.

The administration, faculty and institutional support groups of Grand Rapids Community College have embraced the goals of the MTPC and are currently supporting several activities that will allow the college to accept an emerging role in the preparation of future teachers.

**How Grand Rapids Community College Has Responded to MTPC Goals**

GRCC has responded to MTPC goals in three areas:

1. designed a new course in Physical Science (PC-101) aimed at future teachers and updated an existing course in mathematics, Mathematics for Elementary Teachers (MA-210);
2. created the Grand Rapids Community College Teacher Education Pathway and established the GRCC Teacher Education Center;
3. joined in a local alliance with Grand Rapids Public Schools and Grand Valley State University for the purpose of recruiting and supporting minorities in mathematics and science teaching.

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**How GRCC Has Responded to M55L/MTPC Goals**

- **New Courses**
  - Promoting Understanding through active learning
  - PC 101
  - MA 210
  - Accepted/Supported by transfer institutions

- **New Teacher Prep Curricula**
  - Classroom observations early in degree program

- **Equitable Practice**
  - Focus upon underrepresented groups
  - ATEP at GRCC supported by Eisenhower Grant (Partial)

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*Michigan Statewide Systemic Initiative*
*Michigan Teacher Preparation Collaborative*
New Courses

Driving Forces

In their article *The Role of Community Colleges in the Professional Development of Science Teachers*, Susan Loucks-Horsley, Rodger Bybee and Ellen Wild report that 44% of our nation's teachers begin their academic careers in community colleges [1]. For many elementary teachers community colleges will provide the only mathematics and science courses they will take on their way to a degree. It is imperative that these courses prepare future teachers to effectively meet state and national standards. Since beginning teachers typically teach the way they were taught, community colleges must respond by creating mathematics and science courses that are taught in ways that model the kinds of good teaching described in methods courses but too seldom experienced by the future teacher.

K-12 science education in the state of Michigan focuses on three content areas: Life Science, Earth Science, and Physical Science. GRCC currently offers courses in Life Science and Physical Science. A recommendation to write a new Earth Science course is pending the hiring of new faculty in this area for the fall 1998. Faculty from Life Science and Physical Science taking an active interest in new course development include a Michigan Science Teacher of the Year.

Physical Science (PC-101) was developed explicitly to meet the science transfer requirements of pre-service elementary teachers. PC-101 represents one attempt to teach science in ways envisioned by the MTPC and was selected by the National Science Foundation as an Exemplary Activity in the preparation of teachers. In its developmental stage, faculty from two Big Ten institutions and four regional transfer institutions were consulted on content, story-line, and teaching methods. In addition, the content and activities used in every class were matched with specific objectives taken from the *Michigan Essential Goals and Objectives for Science Education*. Three faculty members teach the five sections offered each semester. It is not uncommon to see more than one faculty member in the classroom participating in classroom activities with the students.

Content and Story-line

Content for PC-101 is taken from Chemistry and Physics. Matter, energy and the conservation laws form broad themes into which specific topics are organized.
philosophy that less is more, this course starts with the Story of the Atom and subsequently uses invisible atoms and their parts to describe and explain phenomena in the students’ everyday world. A key player in the Story of the Atom is the electron who leads students into discussions of the periodic table, bonding and chemical reactions. The electron continues to hold center stage as the content gently moves from the chemistry of batteries into the realm of electricity and physics. Here students use batteries, bulbs and wires to discover the concepts of simple circuits and current.

Use of Real World Contexts in an Activity Based Format

It’s simple: a law, theory or concept isn’t taught if it can’t be linked to a real world context. As an example, last winter a local food chain introduced a new product, Heater Meals. This product uses a flameless ration heater (FRH) like those found in military food rations as the source of heat energy. Within two weeks the energy unit of PC-101 was rewritten to include a laboratory activity determining the heat output from a Heater Meal. Of the thirty class periods available, students are engaged in hands-on activities in over twenty class periods.

A Typical Lesson: Using Heater Meals to Teach about Energy

Informal classroom research on the entering conceptions of PC-101 students shows that many bring misconceptions about the source of heat energy liberated from exothermic reactions like the Heater Meal reaction. These misconceptions arise from confusion between nuclear and chemical changes. Discussions with students lead us to blame many years of high-tech sci-fi movies for this misconception. Many students believe that the energy liberated during the Heater Meal reaction comes from the conversion of matter into energy, a nuclear change, rather than a chemical process involving the breaking of existing bonds and the formation of new chemical bonds. Chemists know that heat energy is liberated during the latter step. To help students acquire the scientific conception they participate in the following activities:

• classroom discussions about the differences between physical, chemical, and nuclear changes highlighting common misconceptions surrounding the topics of heat and temperature.
• watching a video animation depicting the formation of hydrogen gas by the sharing of electrons in a covalent bond.
• reading and summarizing an article on Heater Meals in which the chemical reaction and sources of the heat energy are carefully described.
• conducting an experiment using a computer, a temperature probe, and a piece of a flameless ration heater to determine the amount of calories generated per gram of material.
• carefully describing the reaction process focusing upon the formation of bubbles which contain hydrogen gas.
• discussing the experiment with classmates and writing a clear statement explaining the source of the heat energy.

Collectively, these activities give students the opportunity to construct, use, and reflect upon their scientific knowledge.

New Curricula in Teacher Preparation

The Teacher Education Pathway at GRCC

The GRCC Teacher Education Pathway is a guide designed to help students make decisions about a career in teaching. The Pathway is an action plan for future teachers leading to an Associate Degree. The Pathway provides a list of suggested courses accepted by a majority of our transfer institutions. Features of the Pathway include a brochure on the teaching profession that serves as a recruiting tool while providing information such as: Why People Teach, Opportunities in the Teaching Profession, Who at GRCC is There To Help You and What To Do First.

Perhaps the most important component of the Pathway is the list of Faculty Mentors who have stepped forward to assist in the recruitment and support of future teachers. For many, joining the Faculty Mentors was a reaffirmation of the dignity of the teaching profession. Finally, GRCC is looking to re-tool course offerings in Education that were shelved during the teacher glut of the 70's. The Teacher Education Pathway has rekindled an interest to reopen these courses. Over twenty faculty, representing every discipline, have expressed an interest in developing and teaching these courses.

The GRCC Teacher Education Center

Grand Rapids Community College is currently preparing to open the Teacher Education
Center as the hub for Pathway activities. The Center will begin baseline data collection on elementary and secondary teacher education candidates during summer 1998. The Center will serve as a meeting place for education majors. Center staff will provide the first round of academic advising, and link students to the Counseling Department, Registrar’s Office and Financial Aid Office. Faculty Mentors are given the option of holding one of their office hours at the Center.

Equitable Practice: Focusing Upon Underrepresented Groups

*The Formation of a Local Alliance: An Experiment in Education*

In 1995 the MTPC suggested the formation of local alliances as a way of taking mathematics and science reforms out of the colleges and into the communities which they serve. Statewide, the statistics on the number of minorities entering the teaching profession were disturbing. Even worse was the small number of minorities choosing careers in math and science teaching. With a majority of their current minority staff within five years of retirement, Grand Rapids Public Schools is facing a critical shortage of minority teachers, particularly in the areas of mathematics and science. Unfortunately, Grand Valley State University, our local public teacher preparation institution, only graduated three minority teachers out of 135 in 1997 — none in mathematics and science. Of the 600 designated education majors at Grand Rapids Community College (1997–1998) only three minority students indicated an interest in teaching mathematics and/or science.

In 1996 Grand Rapids Community College began exploring the possibility of entering into a local alliance with Grand Rapids Public Schools and Grand Valley State University to recruit and support minorities in mathematics and science teaching. Grand Valley State University is the transfer institution of choice for Grand Rapids Community College students. Over the course of one year, MSSI representatives from these institutions met and discussed the need and role of each institution in the alliance. The alliance, if it were to succeed, would have to buck a history of prior failures. With a shared vision, a realistic evaluation of the resources available, and a commitment of key personnel, MSSI representatives submitted a successful Eisenhower Grant proposal to support the West Michigan Alliance. **Helping Grand Rapids Home-Grow the Next Generation of Minority Teachers** became the alliance motto and has helped keep the vision of community service ahead of turf issues and personal agendas.
ATEP: The Umbrella Program that Closes the Loop

The key for success was a mechanism to close the loop in a pathway that started with Grand Rapids high school students and ended with these same students employed as teachers by Grand Rapids Public Schools. ATEP is an acronym for the AHAANA Teacher Education Program where AHAANA stands for Asian/Hispanic/African-American/Native American. The goal of ATEP is to recruit and support minority students into all areas of teaching, especially mathematics and science teaching.

ATEP operates within Grand Rapids Public Schools and Grand Rapids Community College. Students leaving ATEP enter Minority Teacher Education Center (MTEC) Programs at Grand Valley State University. In its first year of operation, ATEP hopes to be the vehicle that can create a cohort mentality among the participants at each institution.

Components of Success

Optimism for success is high among alliance members as cooperation is extending up and down the pipeline. Alliance members have pooled resources to hire an ATEP coordinator housed in the main offices of Grand Rapids Public Schools. Grand Rapids Public Schools has also appointed a YES Club (Young Educator Society) coordinator for the district to help oversee the development of YES Clubs at the four public high schools in the Grand Rapids Public Schools.

Grand Rapids Community College is developing ATEP at GRCC as an extension of that operating in Grand Rapids Public Schools. As a companion program, ATEP at GRCC will offer opportunities for financial aid, mentoring, education seminars for ATEP participants, and a carefully designed program leading to a seamless transfer into MTEC programs and the College of Education at Grand Valley State University. In the fall 1998, community college and university representatives will begin planning ways to match future teachers from GRCC with student volunteers from Grand Valley State University within Grand Rapids Public Schools’ focus schools.

Grand Valley State University is currently working with Grand Rapids Public Schools to develop focus schools in science and mathematics for the placement of pre-service student volunteers and student teaching assignments. YES Club students, student teachers, and their
advisors will share planning times for informal discussions and seminars related to the teaching profession. Plans are being made for future teachers from GRCC ATEP program to help staff Pre-College Summer Science Camps held on the campus of GRCC.

Conclusion

In the past six years, Grand Rapids Community College has grown from a college of 6,500 to over 13,000 students. Education currently ranks third on the top ten list of declared majors. Enrollment figures from summer registration 1998 indicate that over 300 incoming freshpersons are interested in the teaching profession. This is an exciting time to be developing education programs as national, state, and local recruiting efforts refocus public sentiment on the importance and dignity of the teaching profession. In three years, Grand Rapids Community College has moved from the information gathering stage through the planning stage and into the implementation stage of new courses and programs. Grand Rapids Community College together with its K-12 and University partners is confident that this experiment in collaboration will be successful.

What started six years ago as an attempt by the NSF to improve the teaching of science and mathematics within the state of Michigan has reached the only level where systemic change can succeed — the local level. The progress of Grand Rapids Community College in the preparation of future teachers stands as a testament to risk taking on the part of the NSF to fund statewide initiatives that empower those with the willingness to work with the resources to carry out systemic change.

References

PRE-EDUCATION PROGRAMS: A COMPREHENSIVE PROJECT AT HENRY FORD COMMUNITY COLLEGE

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Henry Ford Community College (HFCC) in Dearborn, Michigan is a two-year institution of higher education serving a diverse student population of approximately 13,000 students. In addition to providing a broad array of technical and vocational programs, the College provides the first two years of a baccalaureate program. However, the transferability of these programs is not assured. In the absence of a mandated state-wide curriculum, two- and four-year colleges and universities in Michigan develop courses and programs independently, and the transfer of courses between institutions is determined independently by the respective departments. The end result is often loss of credit when a community college student transfers. Other problems faced prospective education majors as well. Students were justifiably apprehensive about the suitability of their academic preparation for the challenges they would confront at the four-year institution. To address this and other problems, HFCC initiated a comprehensive project to develop a structured teacher education program. The project consisted of two components: 1) creation of pre-education programs and 2) institution of articulated transfer agreements as a result of collaboration with neighboring universities. The success of this reform is underscored by a dramatic increase in HFCC pre-education majors from 354 students in 1994 to 697 in 1997, with 80 students designating minority status in 1994 and 179 in 1997.

Background

Prior to 1992, Henry Ford Community College offered some courses that satisfied general education requirements and a few courses designed for prospective teachers, such as Art for the Elementary Teacher or Mathematics for Elementary Teachers I and II. Students often expressed concern about course transferability, the State of Michigan mandated testing, and student teaching. Students expressed a need for guidance, for structure, for community. To address that need, the Future Teachers’ Association was founded in 1992. In 1993, the Michigan Statewide Systemic Initiative-Teacher Education Redesign Component (MSSI-TER), a statewide committee whose goal was the redesign of the mathematics and science curriculum for prospective teachers, invited HFCC to send a representative to serve on the Community College team. Through this involvement, the College became aware of the changing curriculum at four-year institutions in the state that would adversely affect community college students, making it difficult to transfer credits and prolonging the work
necessary to attain a bachelor’s degree and teacher certification. To best serve education majors, the College had to respond in a positive and constructive way. After much discussion, it was decided that the College would develop Pre-Education programs that would provide a seamless transition from the community college to a university curriculum in education.

The Inception of the Program

Because HFCC and the University of Michigan-Dearborn (UM-D) are next door neighbors, an initial meeting took place between representatives of both institutions in September 1994. The discussion focused on the feasibility of course and program development and on UM-D’s receptivity to collaborating on this project. Dr. John Poster, Dean of UM-D’s School of Education, was very receptive to HFCC pursuing a program that would enable students to complete two years of course work (60 - 62 credits) at HFCC which would satisfy course requirements at UM-D. In addition, the development of such a program would nurture the Dearborn Public Schools’ Career Ladder Pilot Project, a concerted effort to locally prepare a cadre of paraprofessionals to become bilingual teachers in Dearborn. With this understanding in place, the Pre-Education Committee, a committee of HFCC faculty, was formed to guide the development of the program, the creation of new courses, and the revision of existing courses. The committee met monthly to share ideas, to discuss progress in course and program development, and to set goals for the following month. The result of this work was a 60-credit community college program that parallels the work done the first two years by university students before they are admitted to an education program.

Program Development

As with every aspect of this project, much research preceded the drafting of the program. The committee studied the education programs at several universities, including the College’s primary transfer institutions. Because HFCC prepares students to transfer to a number of universities, the committee desired to have a program that would be comprehensive yet flexible enough to serve all of the College’s students. In addition to the needs of the universities, the committee recognized other issues. First was an increasing desire of school districts to employ more highly trained education paraprofessionals. This issue has two parts: providing those already in the field with opportunities to increase their knowledge and skills
and so be better able to serve elementary school children, and providing training for people desiring to be employed as education paraprofessionals. The committee also recognized the special need of the Dearborn Public School district to employ bilingual teachers and the initiative within the district to encourage education paraprofessionals to pursue their teaching certificates.

Therefore, in 1995, Dearborn and several other school districts were surveyed regarding their desire for a program for education paraprofessionals. These surveys queried principals, directors of paraprofessionals, and superintendents of school districts about course work that would benefit paraprofessionals and the optimal length of a program of study for this group of aides. Based on all research, a two-step program was developed. The initial step was the 32-credit Certificate of Achievement for Education Paraprofessionals. This program includes courses to enhance students' content knowledge in the specific areas of children's literature, English composition, mathematics, and science. Introduction to Psychology, Educational Psychology, Instructional Technology for Elementary Teachers, First Aid, and Assisting with Elementary Reading are intended to promote the development of interactive skills necessary for working with children. This certificate can be used as a terminal course of study or it can provide the foundation for the 60 to 62-credit Associate in Arts in Pre-Elementary Education.

The Associate in Arts in Pre-Elementary Education was designed to have three components: core courses, general education courses, and electives. The core and general education components satisfy associate degree requirements and are a part of the elementary education curriculum at all HFCC four-year transfer institutions. These courses are a part of the elementary education curriculum at all HFCC four-year transfer institutions. In addition to the courses required for the Certificate Program, additional composition, mathematics and science courses are part of these components. A political science course and five additional hours of humanities electives are included. Assisting with Elementary Reading and First Aid are not required in the Associate Degree program. The 23-credit hour elective component provides flexibility so that students can complete required course work for the transfer institution of their choice. To assist students, the general Pre-Elementary Education Program is adapted to meet the needs of each transfer institution that has collaborated with the College. These adaptations specify other required courses and more focused elective choices for the particular university.
Upon completion of the degree, a student has met all or most of the general education requirements of the four-year institution, has begun work in major and/or minor teaching areas, and has credits that apply toward education courses. By design, the student leaves HFCC with a minimum of 45 hours of observation in K-12 classrooms and some insight into the teaching profession.

Other Program Development

With the Pre-Elementary Education Program in place, a need for Pre-Secondary and Pre-Special Education programs became apparent. The committee repeated the research and development process and the additional programs were created.

Course Development

The collaborative process has proven extremely effective in creating courses that transfer as equivalent university courses. To service the programs, four new courses were developed: Assisting with Elementary Reading, Children’s Literature, Instructional Technology for Elementary Teachers, and Introduction to the Humanities. Additionally, the Educational Psychology course was revised to meet transferability requirements.

Redesign of Mathematics for Elementary Teachers

From the earliest stages of program development, mathematics educators have been attuned to the changing curriculum in K-12 classrooms. This change has been dramatic, not only in content, but also in desired outcomes and methods of teaching and learning. The curriculum has been expanded to include topics such as data analysis, relations and functions, transformational geometry, and probability. Objectives now include a focus on the understanding of concepts, the ability to problem solve, and the ability to express mathematical ideas in appropriate written and spoken language. Delivery modes emphasize more student-centered learning environments. In short, the K-12 mathematics classroom of 1998 does not resemble the K-12 mathematics classroom of five, ten or twenty years ago. Preparing prospective elementary teachers to be successful in an environment very different from the classroom they remember is a task that embraces many facets. Recognizing the
importance of this task, a committee of mathematics educators at HFCC set out to redesign the mathematics content courses for prospective elementary teachers at the College.

The committee began its task by researching the current state of affairs. To this end, the committee examined textbook series for elementary schools published by Addison-Wesley, Macmillan, and Silver-Burdett, and syllabi for similar courses at neighboring universities, including UM-D and Eastern Michigan University (EMU). Other relevant documents examined included:

- *State of Michigan Guidelines for Mathematics Content K-6*.
- *Michigan Test for Teacher Certification (Basic Skills Test)*.

In addition, the committee discussed course development with mathematics educators from teacher training institutions and with inservice elementary school teachers. Typical questions asked of university faculty included:

- What direction do you want Mathematics for Elementary Teachers (MET) courses to take at your university?
- What content do you think is important?
- What text and ancillary materials do you use?
- What teaching styles do you utilize in your MET classroom?
- How will the MET courses be structured at your university?

Typical questions asked of inservice teachers included:

- What do you remember learning in your MET courses?
- What do you wish you had learned in your MET courses?
- What can mathematics educators do to better prepare prospective teachers for the modern mathematics classroom?

Based on all findings, committee members instituted a prerequisite of Intermediate
Algebra for the course sequence and identified the topics to be addressed in the MET courses. This level represents the mathematical competence of a high school student who has completed two years of algebra. Thus, prospective teachers have an understanding of the mathematics for which they are preparing their students. Anecdotally, instructors have found that with this prerequisite, students are now better prepared to handle the abstraction and concept development critical to the course materials. Another factor in deciding on an Intermediate Algebra prerequisite was the requirement of some four year institutions that community college MET courses have such a prerequisite, thus ensuring transferability.

The content for the prospective courses was discussed at length. Clearly, the increased coverage of geometry, probability, and data analysis in the K-6 curriculum dictated an increase in geometry topics and the inclusion of probability and data analysis. Integrating Geometers' Sketchpad and LOGO into the curriculum provided a vehicle for learning geometry and for modeling interactive learning.

With the increase in content, the seven credit hours used for the Math 120 - 123 sequence was inadequate. The committee discussed increasing the number of credits to eight or nine. Also, three options for the structure of an MET sequence were discussed. Two of the options involved two courses, either one five-credit course and one four-credit course, or two four-credit courses. The final option was to have three courses of three credits each.

Arguments for the first two options were based primarily on scheduling. Four and five credit hour courses were appealing to faculty for their schedules, and students would be able to complete their math content more quickly. On the other hand, having students in math content courses for three semesters would keep students in an environment nurturing mathematical inquiry for a longer period of time. Weighing these options and the ease of transferability to the major transfer institutions, the committee decided to create three three-credit-hour courses.

Major changes in the curriculum are the addition of topics such as data analysis, relations and functions, probability and statistics, and spatial visualization as required subject-matter. There is an emphasis on reading, speaking, and writing mathematics. Additionally, the structure of the classroom time has significantly changed. There has been a shift from
primarily lecture style where students are relatively inactive participants to an environment where much class time is devoted to cooperative learning exercises, guided discovery lessons, computer activities emphasizing the discovery of concepts, and whole class discussions.

Student assessment now includes assignments, journals, projects, and tests. Assignments involve explanation of mathematical concepts and processes, reading of mathematical content not presented in class and application of this content. Articles from *Teaching Children Mathematics, Mathematics in the Middle School*, or *Research within Reach* may be assigned with the students answering follow-up questions. Assignments also require problem solving, explanation of solutions, and creation of original problems. Journals are used to encourage students to summarize and reflect on their daily work. Students are encouraged to note successes and difficulties. Journals help to develop a reflective attitude in students. Projects provide students with the opportunity to explore a topic in depth and to further develop communication skills.

With these courses in place for three semesters, we are seeing that along with the main course objectives, many by-products are being achieved. Students are learning in an environment where multiple delivery modes are being used. They are using manipulatives, calculators, and computers to explore and discover mathematical concepts. In addition they are reading, writing, and speaking mathematics. Working in cooperative learning groups, students are experiencing the positive and negative aspects of this learning environment, experiencing the frustration, the excitement, and the joy in discovering, understanding, and achieving.

In a draft of the Michigan Statewide Systemic Initiative - Teacher Education Reform (MSSI-TER) document, "Preparing Teachers for a Changing World: Guidelines for Science and Mathematics Teacher Preparation in Michigan", an example was presented of a fundamental weakness many people experience with division of fractions. Although students are familiar with the standard algorithm that to divide by a fraction, one multiplies by the reciprocal of the fractional divisor, they often cannot write a word problem that requires division by a fraction. That is to say, students do not understand the concept of division by a fraction. In Mathematics for Elementary Teachers II, students use fraction bars and pattern blocks to explore the concept of division by fractions. Students, without exception, see the
connection between the model of division of whole numbers where a larger set is divided into smaller sets and dividing a fraction into sets whose size is a fraction. Once students have exclaimed, “Cool, this really works!”, they question how the algorithm was developed. Reflecting on the definitions of fractions, fraction as indicated division is selected to write a division problem as a complex fraction. Simplifying the denominator of the complex fraction to the value one (1) involves multiplying by its reciprocal. Hence, \((a/b / c/d) \times (d/c / d/c) = (ad/bc) / 1 = ad/bc\). Students know the mathematical process that was abbreviated to the algorithm commonly used. Now when posed with the task to write a word problem that requires division of fractions, students can successfully write such a problem and explain why division by a fraction is used to solve the problem. When given an assortment of word problems involving operations with fractions, students are less confused as to which operation is appropriate.

Courses are reviewed by individual instructors each semester and by the MET committee each year. One aspect of the assessment of the courses and the MET sequence is based on formal and informal evaluations by students in their journals and at the completion of the courses. Another is feedback of the individual instructors. A third aspect of assessment is ongoing communication with mathematics educators at four-year institutions regarding appropriate course content and teaching technique. Based on this, the committee has made many recommendations, including: the extent to which certain topics are covered, the integration of some topics, and the omission of certain topics. In addition, the committee remains committed to keeping the MET sequence current with new ideas and developments in mathematics education. The ongoing discussions and exchange of ideas with mathematics educators from other institutions help the courses continue to develop and improve, and so serve the needs of our students.

**Collaborative Efforts in Mathematics Education**

In addition to discussions about curricular issues, neighboring universities have been receptive to engaging in collaborative efforts with HFCC. During winter 1998, two projects involved HFCC students with university and K-12 students. The first project partnered UM-D and HFCC students with K-12 students from the Dearborn and Detroit Public School Districts. The Local Alliance of Dearborn and Detroit Educators for Recruitment and
Success (LADDERS) was a mechanism for university students, community college students, and high school students to work collectively on developing and delivering mathematics activities for elementary students. Through LADDERS, many objectives were set, including the following: to provide a bridge from the community college to the university; to encourage community college students to select mathematics as a teaching major or minor; to attract high school students from underrepresented groups to the career of mathematics teaching; to expose prospective teachers to the environment of the urban classroom, thus acquainting them with the culture, challenges, and rewards of teaching in the urban setting; and to encourage prospective teachers to select the urban setting as their desired teaching setting. An Eisenhower Proposal was submitted July 1998 that outlined an enhanced project based on this work.

A second initiative involving Eastern Michigan University (EMU) and HFCC is funded by an Eisenhower grant. This project has prospective elementary teachers from both institutions and elementary school children from Detroit Public Schools visiting the Museum of African-American Art in Detroit. Geometry activities for elementary school children will be developed based on the art viewed. Prospective teachers will interact with the children in completing these activities. After working with the children, prospective teachers will reflect on the experience and revise the activities to improve them for the next presentation. Faculty from EMU and HFCC will work with Detroit Public School teachers on the content of the activities and on appropriate strategies for classroom use. This unique experience is an exciting opportunity for the prospective teachers designing the activities, the faculty from both institutions involved in the project, and the elementary school children who will visit the museum and engage in the activities.

Articulation Agreements

An extremely important motivation for the development of the Pre-Education Programs is the seamless transition from the community college to four-year institutions. Because education programs are so extensive, it has been a goal of the project to transfer each HFCC course as an equivalent course in the four-year institutions' education programs. This eliminates the transfer of credits as general electives or elective credits that may not satisfy program requirements or may not apply towards the teaching major or minor. Consequently,
students transferring from HFCC will be able to complete their bachelor’s degree having earned the same number of credits as students who begin their work at a university. To ensure this efficient transfer, HFCC is working to develop articulation agreements with four-year institutions. To date, articulation agreements with UM-D, Wayne State University, and Marygrove College have been signed for Pre-Elementary Education and Pre-Secondary Education Programs. Strong transfer guides have been developed with other universities and discussions continue with institutions as they reconstruct their programs.

The work on articulation agreements has benefited HFCC students in that it has established communication between the College and schools of education. It has also increased university awareness and transferability of newly developed or revised courses. Discussion of co-advising practices and linking university and HFCC advisors, promise to maintain communication about programs and more importantly, to alert the university of a student’s impending transfer. Referring students to a designated university advisor, who is knowledgeable of the HFCC/university collaboration will smooth the transition for these students.

Student Support

Designing the Pre-Education Programs has been an important first step in providing support for students pursuing a career in education. Along with the transfer and articulation agreements that are being developed, these programs lay the foundation for further work. To enhance the success of its diverse and non-traditional student population, HFCC has worked to provide some “extras.”

Advising

As part of the College’s pilot faculty advising initiative, members of the pre-education committee advise program students. Committee members who have worked closely in the design of the program and who have been updated on articulation work at monthly meetings are best suited to guide these students. During advising sessions, the Pre-Education Programs are discussed, as well as the articulation agreements that are in place or that are being negotiated. Discussion of a two-year plan of study takes place demonstrating how the Associate Degree can be achieved and how this degree fits into a Bachelor’s degree at several transfer institutions. Specific sections of courses are flagged and, when possible, students are
scheduled for those sections. The students are informed that other pre-education students are enrolled in that section and are encouraged to meet those students and form study groups.

Scheduling

When scheduling classes, students need not be concerned with scheduling conflicts. Long before the course schedule goes to print, the Coordinator of the Pre-Education Program meets with Department Heads and Division Directors to synchronize scheduling. According to data from a database created for the Program, the number of students who are ready to take specialized courses is available. Based on this information, numbers of sections of courses are determined. A master schedule of pre-education core courses is created so that no conflicts arise and students can establish a compact, efficient schedule. Students notice that their time on campus is used effectively. This is especially helpful to students with families and/or busy work schedules. This careful planning also prevents students from having to increase their number of semesters at HFCC while they wait for course availability.

Community Building

Although compact, efficient schedules for students was the original intention of the orchestrated scheduling, a far more important by-product has developed. Students are forming informal learning communities. As students become acquainted and recognize each other, they move from class to class together, discuss work from other classes, form study groups, and become a strong support system for each other. They make connections between content from different courses. For instance, while discussing the Van Hiele levels of geometric thinking in a Mathematics for Elementary Teachers II class, students spontaneously question how these are related to the Piagetian theory discussed in Child Psychology. When discussing Polya’s steps to problem solving, an introductory topic in Mathematics for Elementary Teachers I, they compare this to problem solving learned in the Introduction to Psychology. Working in communities and comparing content from different courses has created an excitement and enthusiasm for learning that had not been observed before the development of additional courses and the structure of the Pre-Education Programs.

Future Teachers’ Association (FTA)

One of the catalysts of the development of the Pre-Education Programs has become a beneficiary. The Future Teachers’ Association (FTA) has more than doubled its membership
in the past two years. This increase in membership reflects an increase in the number of Pre-Education students at the College. More exciting than the increase in numbers is the broadening of the activities of the club. In the initial years, the club provided a service to students by bringing speakers from universities and school districts to campus. During meetings, students learned important information about university programs, the job market, creating a resume, or interviewing. In recent years, the club has continued to provide educational meetings, but it has also developed a philanthropic aspect. For two years, students have conducted fund raisers and have contributed children’s books for a “Gift of Reading” program. These books have been donated to the Dearborn Public Schools Bilingual and Compensatory Education Program and to the Early Childhood Program. A second humanitarian project is the collection of new toys and stuffed animals for the patients at Children’s Hospital. Students volunteer their time to work in the HOST program, an initiative focused on building the reading skills of early elementary children, as readers for blind students at the college, and as tutors in both public and private schools. These projects are evidence that the Future Teachers’ Association has become both educational and philanthropic in its focus.

**Partners Plus**

Universities with which HFCC has collaborated are very enthusiastic about assisting students in making the transition from the College to their university programs. A partnership between the University of Michigan-Dearborn and HFCC targets minority students in business and pre-education programs. This project, Partners Plus, provides mentoring, tutoring, and general support. Regular meetings of Partners Plus are planned to encourage a sense of community among the students. Representatives from UM-D regularly attend and encourage students to use the UM-D mentoring and tutoring facilities that are available to them. Motivational speakers offer encouragement and strategies to help students succeed in course work. Students in need of financial aid or employment often find assistance through this program.

Wayne State University (WSU) offers tutoring and support services to HFCC students prior to their admittance to the university. Students may use university learning facilities that prepare them to pass the WSU competency tests in mathematics and English. Students will also be invited to a community college day each fall. The purpose of this day is to acquaint
students with the WSU campus and the School of Education faculty.

Program Support

The Pre-Elementary Education Programs impact both the K-12 school districts and the universities. In an effort to monitor the programs so that they continue to effectively address the needs of both arenas, an advisory committee was instituted in 1996. The committee consists of a broad array of professionals from school districts and universities. These educators meet twice each school year to monitor the development and progress made with the Pre-Education Programs. Based on their recommendations, subcommittees are formed to examine issues in greater depth. These subcommittees meet one to three additional times to discuss aspects of the programs and to make recommendations to the College.

Internally, the Pre-Education Committee, the group which initially investigated and developed the programs, continues to meet on a monthly basis. Because the programs are still young, this committee continues to address issues of assessment, brochures, and course development. Ways of enhancing the program and of serving students more effectively are being reviewed and tested. The Pre-Education Committee continues to be the thrust behind the programs.

Impact on Students

Prior to the creation of the Pre-Education Programs, students experienced much apprehension about the transferability of HFCC courses, the suitability of their academic preparation for four-year colleges, and the relevance of their course work to K-12 classroom practices. Although transfer guides were available, students were uncertain that their course work would transfer and doubted whether it would prepare them adequately for the rigors of four-year colleges. Given that few content classes were directly tailored to education and that students had little or no exposure to K-12 classrooms, education majors could not gauge the relevance of their instruction to the actual practice of teaching. Perhaps most importantly, education studies students lacked a sense of community with other students.

Transfer of Courses

Student concern about the transfer of courses was well-founded. No mandated state-wide
curriculum exists in Michigan. Consequently, two- and four-year colleges and universities in the state develop courses and programs independently, and the transfer of courses between institutions is determined independently by the respective departments. Often, students completing associate degree programs of 60 - 62 credit hours discovered that as few as 40 of those credits transferred to a four-year school and even fewer applied toward a teacher preparation program. In 1994, the University of Michigan-Dearborn notified HFCC that only 20 HFCC credits could be applied toward the Bachelors Degree in Elementary Education. However, the development of the Pre-Education Program improved dramatically the transfer of HFCC courses. The University of Michigan-Dearborn agreed to transfer all 60 program credits and confer junior status upon all HFCC students who completed an Associate in Arts with a concentration in Pre-Elementary Education with a 2.75 grade point average and a passing grade on the mandatory Michigan Test for Teacher Certification Basic Skills Test. Similar scenarios can be sketched for other major transfer institutions. The impact is a significant increase in HFCC credits that apply toward teacher preparation programs, and a significant decrease in lost credits upon transfer to a four-year school. For students, this means an efficient use of time and education dollars.

Students are now reassured that their course work will transfer and apply toward teacher education program requirements. Student reports of successful transfer have generated increased confidence in the program, one factor leading to increased student retention.

Alliances and Academic Preparation

Partnerships between universities and HFCC have led to the creation of a curriculum designed to prepare the student academically as well as to smooth the transition from HFCC to the university environment. These partnerships focused on enhancing mathematics curriculum at the elementary level, creating service learning experiences for community college and university students, and recruitment of prospective teachers to mathematics education in an urban setting. HFCC built a bridge. As the prospective teachers developed lessons, university students shared information about courses, program requirements, and student teaching. (Yes, they even made recommendations about professors!) This interaction has smoothed the transition from the College to university settings by establishing a familiarity with the respective campuses, by introducing the students to university faculty, and by creating mentoring relationships with university students. Additionally, students are exposed
to K - 12 classrooms and learn how to work in a multi-institutional effort.

Introduction to K - 12 Classroom Instruction

Henry Ford Community College Pre-Education students are exposed to teaching as a profession in the first two years of study and consequently gain familiarity with a K - 12 classroom setting prior to transferring to a four-year institution. Courses such as Children's Literature, Educational Psychology, Instructional Technology for Elementary Teachers, and Mathematics for Elementary Teachers give students an important insight into course work specific to teaching majors and minors. Service learning and practicums require students to observe or actively participate in K - 12 classrooms, thus providing exposure to teaching. Students learn whether teaching is right for them early in their college experience. Again, another means of using time and education dollars efficiently. They also have the opportunity to work in several classroom environments to determine at what level they would like to teach. Consequently, important impacts of the program are student awareness and commitment to the teaching career.

Community Building

Academic advising and coordinated scheduling enable Pre-Education students to form informal learning communities. Students work together on assignments, study together for tests, and support each other when illness, work schedules, or family commitments prohibit them from attending class. This interaction nurtures student success.

Overall, the program has created an enthusiasm for learning among faculty and students, a sense of structure and reassurance in course transferability, and it has provided an opportunity for practicum experience early in a student’s college career. Collaborative efforts such as LADDERS, the EMU Eisenhower work, and Partners Plus create opportunities for students to experience innovative learning techniques. These efforts open the door to interaction on the university campus and at K - 12 schools, exposing HFCC students to university students and faculty and the K - 12 environment.

Impact on Community

The work done at HFCC in the area of teacher preparation has impacted many
communities in a variety of ways.

**Henry Ford Community College**

To focus on the College community itself, the Pre-Education work has influenced the College at several levels. The Mathematics Division has observed the work done by the Mathematics for Elementary Teachers Committee in the research and development of a new course sequence. As a result, this committee process has become a formal part of the Division. As of Fall 1997, six curriculum committees have been formed, each addressing the specific needs of a cluster of courses. The committees are charged with the tasks of review and redesign of curriculum, investigating appropriate delivery systems, text selection, and any other topic relating to their courses which may improve those courses.

Looking beyond the Mathematics Division, the ongoing committee work has been a model for program design, collaborative work with universities, and articulation agreements. The interdisciplinary approach to the project has enriched not only the committee, but the College as a whole.

**School Districts**

The impact of the Pre-Education programs is felt beyond the HFCC campus in surrounding school districts as well. Individual children are being influenced by the presence of HFCC students who observe or act as tutors and mentors because of course requirements, local alliance activities, or volunteer work through the FTA.

Education paraprofessionals from at least eight school districts are pursuing programs at HFCC to strengthen their effectiveness in the classroom or to provide the foundation for a bachelor’s degree, teacher certification, and a teaching career. Although many basic courses could provide this foundation in previous years, the articulated programs make the process more efficient. The existence of formal programs also makes more people in the community aware of the opportunities provided by the courses and the programs. Paraprofessionals find that the courses developed for the program are extremely helpful and applicable to their daily classroom work.

**Four-year Institutions**

Interaction between the universities and HFCC has been beneficial to all parties. Course
development has catalyzed discussion among faculties. In areas such as mathematics and science, this has enabled faculty to interact and learn from each other in an era when curriculum changes are dramatic. Through discussion of content and methods and the exchange of successful and not so successful strategies and ideas, these partnering efforts have been beneficial to faculty and students alike.

Although the program has not been in existence long enough to see any trends in data, qualitative feedback indicates that HFCC students are acclimating well when reaching their transfer institutions. Mathematics faculty from neighboring institutions note that HFCC students are as well prepared, and at times, better prepared than native students. By sending well prepared students, HFCC is having an impact on the university classes and programs.

Other Michigan Community Colleges

On the state level, the work in Teacher Preparation at HFCC has influenced other community colleges to pursue the same endeavor. An important result of MSSI-TER is the collaboration of faculty from several colleges across Michigan. Community College Conferences for three consecutive years have been a forum for the exchange of ideas on curriculum, programs, and articulation work. At each conference, HFCC has presented its work, acting as a motivator for other community colleges to pursue the development of teacher education programs.

Successful Strategies

Without a doubt, the careful, collaborative approach to the development of the Pre-Education Programs and to course development is the most important strength of the work done at HFCC. As summarized above, the programs were carefully developed by a committee of faculty from across the College, with the assistance and guidance of Dr. John Poster, Dean, School of Education, University of Michigan-Dearborn. Careful research of education programs and guided development has resulted in a program that fits all major transfer institutions and provides a balance of general education requirements, major and minor course work, and education courses enabling students to determine early in their college career whether teaching is appropriate for them.
Working with university faculty in the development of courses generally proved to be rewarding for all parties involved. Discussion of content, modes of delivery, course structure, and textbooks helped flush out important ideas and helped create strong courses. With university input, transfer of courses was a natural result. Conversation continues between faculty, ensuring ongoing relationships, and further nurturing the improvement of courses. Interchange of ideas, especially in the mathematics education courses, has been especially exciting. Sharing supplemental activities and readings, exchanging classroom experiences, and interacting in the local alliance activities has created a dynamic environment in which faculty and students learn.

Now that the programs are established, monitoring program revision are essential to keeping them current and effective. The Pre-Education Committee, consisting of HFCC faculty, continues to meet each month. From these meetings, assessment criteria, recommendations for a new brochure, creation of a newsletter to program students, and exploration of formal learning communities are a few of the tasks recently undertaken. Overseeing the programs, the advisory committee, consisting of representatives from K-12 school districts, universities, and the College, offers recommendations regarding the education paraprofessional certificate of achievement program and the degree programs. This year the committee targeted the development of continuing education courses, marketing of the program, and creation of a developmental semester and formal learning communities. Subcommittees will be reconfigured based on recommendations from the full committee and possibly requests from the College. Based on the first one and one-half years, the advisory committee has brought important knowledge and insights to assist in maintaining quality programs. Proactive interaction with admissions offices and schools of education to gain transferability of courses and to initiate articulation agreements has hastened progress in this area. Again, communication of course content beyond a catalog description has enabled university personnel to recognize the quality, and often the equivalence, of HFCC courses to their courses. Without the active involvement of HFCC faculty, the transfer of many new courses may have been overlooked.

The Career Ladder program encourages education paraprofessionals in the Bilingual and Compensatory Education Program in the Dearborn Public School district to pursue course work that enhances their skills in assisting elementary classroom teachers and working with
students. Because of a fringe benefit in their contract, Dearborn paraprofessionals may take classes at HFCC at no tuition cost. Before the Pre-Education Programs began, paraprofessionals could complete fundamental courses at the College, but had no exposure to courses specific to an elementary education program. With the Education Paraprofessional Certificate of Achievement and the Pre-Elementary Education Degree Program, these paraprofessionals have a stronger foundation before moving on to the university. Also, they are exposed to content that can be applied everyday to their job in the classroom. This career ladder has been successful in encouraging Dearborn paraprofessionals to pursue course work and teacher certification so that they advance to the career of classroom teacher.

Along with the positive effects of program articulation and course transfer, the affective aspect of this program development has been important. Faculty advisors who have been involved in program development and articulation agreements provide students with valuable information about their time at the College and beyond. This includes details about the Pre-Education Programs, the collaborative work done with universities, and a plan of the courses a student can complete at HFCC before transferring. Targeting sections of courses for pre-education students allows these students to become acquainted, work together, and schedule classes together in future semesters.

More formally, the coordinated scheduling of courses specific to the program has been very effective. The courses have filled to capacity and students have been very pleased with their compact, efficient schedules. This is especially important to the returning students, the students with busy work schedules, and family responsibilities. A by-product of this scheduling has been the formation of groups of students who attend class together, study together, and socialize together. These students have immersed themselves in an environment where their course work has dictated other controllable aspects of their lives. Their learning has become a central focus of their lives.

Also addressing the affective side of this project are support groups such as the Future Teachers’ Association (FTA) and Partners Plus. Both organizations provide valuable information and a support structure. FTA offers opportunities for philanthropic projects as well as projects that involve tutoring or working with students who require special assistance. Partners Plus, focusing on minority students, provides mentoring and tutoring to students,
assists students in securing financial aid and scholarships, and helps students find part-time employment to help defray the cost of their education. Both groups provide a sense of community and support that nurtures students.

Assessment

Assessment models for the Education Paraprofessional Certificate of Achievement and the three Associate degree programs have been developed. The Education Paraprofessional Certificate of Achievement will be examined based on the following student outcomes:

- The student will be able to successfully secure employment as an educational paraprofessional or in a closely related position.
- Students who wish to continue their pre-education studies at HFCC will be able to successfully complete the Associate in Arts Degree in Pre-Education.
- The student who successfully completes the Associate in Arts Degree in Pre-Education will be able to receive a Bachelor’s Degree in Elementary Education.

These student outcomes will be assessed according to the following criteria (respectively):

- a) Within six months of graduation, 70% of the program graduates who were seeking employment in the field will have been successful in their quest.
- b) 80% of the program graduates who found employment in the field will be judged by their employers to be adequately prepared for the specific tasks required for the position.
  - 60% of students who indicate a desire to pursue the Associate in Arts Degree in Pre-Education and have a cumulative grade point average of 2.50 or above in the certificate program will successfully complete their degree work within a three-year time frame.
  - 50% of students who pursue a Bachelor’s Degree in Elementary Education will complete their degree in six years.

The degree programs have the following student outcomes:

- Students who successfully complete the Associate in Arts Degree in Pre-Education will be able to pass the Basic Skills Test mandated by the State of Michigan.
- Students who successfully complete the Associate in Arts Degree in Pre-Elementary
Education (Pre-Secondary Education, Pre-Special Education) will be able to successfully transfer into an elementary (secondary, special) education program at a four-year institution.

- Students who successfully complete the Associate in Arts Degree in Pre-Elementary Education (Pre-Secondary, Pre-Special) will be able to receive a Bachelor's Degree that will enable them to teach at the elementary (secondary, special education) level.

These student outcomes will be assessed according to the following criteria (respectively):

- 80% of degree recipients will be able to pass the Basic Skills Test on their first attempt.
- 70% of degree recipients who apply to (a school of education at) a four-year institution will be admitted (to a school of education) within one year of graduation.
- 50% of degree recipients who pursue a Bachelor's Degree will be able to complete their degree in six years.

Because the program has been active for one and one-half years, there is insufficient data to determine whether the student outcomes have been met. Even though the program is too young to provide sufficient data about student outcomes, one can examine the numbers of students in the program.

When examining the numbers of students in all pre-education programs, numbers of students enrolled in the program from Fall 1994 to Fall 1997 are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>354</td>
</tr>
<tr>
<td>1995</td>
<td>393</td>
</tr>
<tr>
<td>1996</td>
<td>505</td>
</tr>
<tr>
<td>1997</td>
<td>697</td>
</tr>
</tbody>
</table>

If we examine the numbers of students who register an ethnic or racial status, the following data are available:
While the program is still in its infancy, an encouraging trend seems to be emerging in this data. While white students still constitute the largest single category, the percentage increase in the numbers of Hispanic, Black, and Arabic students is much greater than that of white students. With recruitment efforts in the Dearborn Public Schools for bilingual teachers and programs such as Partners Plus, this could be the beginning of a trend of increasing the minority population of students choosing the teaching profession.

When focusing on the Mathematics for Elementary Teachers courses, the pre-1996 sequence, Math 120-123, had no prerequisite. The success rate of students was approximately 64%. With the prerequisite of the revised Math 121, 221, 225 sequence set at Intermediate Algebra, the content of these courses is more rigorous and the success rate has increased to 76%. Far more important than internal success rates is the success that HFCC students are experiencing at the universities. In recent meetings with colleagues from four-year institutions, positive comments about the preparation of HFCC students have been made. When assessment tests are required, students are doing well and are placing into their methods courses. This informal, qualitative information indicates that the program is producing students who are well prepared for university work.
The College of San Mateo (CSM), a community college serving the San Mateo County area of California, is part of a collaborative effort in the San Francisco Bay Area to improve mathematics and science teacher preparation. With funding mainly through the National Science Foundation, the project is locally referred to as the MASTEP Project (Math and Science Teacher Education Program). MASTEP partners include two California State Universities (San Jose State University and San Francisco State University), four community colleges (College of San Mateo, City College of San Francisco, Evergreen Valley Community College, and San Jose City College), selected K-12 schools, and a number of informal educational institutions and local industries. Activities at CSM include recruitment of future math and science teachers through an active future teachers club; tutoring, mentoring and advising through the activities of an integrated science center; and professional development activities and financial support for science and math faculty resulting in their significant involvement in curriculum reform. As a community college, CSM plays a major role in identifying and supporting future teachers and providing these students with courses that are models of effective teaching.

The Bay Area Demographics

California presently educates 11% of the nation's children and the California State University system (CSU) credentials 75% of the state's elementary and secondary teachers. The service area of the Bay Area collaborative has a population of 3.5 million and educates 11% of California K-12 students. The school districts from San Francisco, San Mateo and Santa Clara counties include a wide range of urban, suburban and rural schools with very diverse ethnic compositions and a total K-12 enrollment of 388,000. Santa Clara County has over 60% non-white students, San Francisco County has 87% non-white students, and San Mateo County has 58% non-white students. As points of comparison, at San Jose State University for the period of 1992-1996, only 19.4% of students receiving a secondary science credential were non-white and 18.6% of students receiving a secondary math credential were non-white [1]. San Francisco State University has a similar enrollment pattern. The College of San Mateo is centrally located between the two California State University campuses and...
acts as a major feeder of students to San Francisco State University, San Jose State University, and other baccalaureate institutions.

The College of San Mateo is part of the San Mateo County Community College District. The area served by the college is in the midpeninsula from Redwood City in the South to South San Francisco in the North. The District also includes Canada College in the South and Skyline College in the North. Total enrollment at CSM for Fall 1997 was 11,687. District statistics for the College of San Mateo show the following percentages for ethnic enrollment for Fall 1997: Asian 19.3%; African American 3.5%; Filipino 6.8%; Hispanic 15.7%; Native American 0.6%; White 48.8%; Other/Unknown 5.3% [2]. According to the County Office of Education, the ethnic composition in K-12 feeder school districts reflect the diversity of the communities that they serve and the majority of students in San Mateo County public school districts are from ethnic minority groups [3]. Overall, the Bay Area suffers from a critical shortage of qualified math and science teachers and the teaching workforce does not represent the cultural and ethnic diversity of the surrounding communities.

Approximately 70% of San Francisco State University and San Jose State University students are transfer students from the California Community College system which is the largest feeder of underrepresented students to baccalaureate institutions [4]. Thus, the MASTEP model includes the active participation of the four major feeder community colleges with the two local State Universities.

Overview of the MASTEP Model

The MASTEP model for the Bay Area is a multifaceted project that includes a number of activities at both the community college level and the university level. Major components of the overall project include 1) recruitment, 2) reform of content and teaching, and 3) new teacher support. The community colleges' involvement in the first two components is extensive.

The goal of the recruitment effort is to identify and attract more students into science and mathematics teaching at K-12 levels, especially those from underrepresented groups. Since the community college is a rich source of ethnic diversity and talents, we play a major role in
The reform of college content and teaching is a component directed to science and math faculty, including the community college faculty. Major elements of the component include: a) a math and science faculty development program, b) formation of collaborative faculty groups to address teaching and learning issues and c) financial support for faculty to engage in developing course enhancements (new teaching approaches, new materials, technological applications) and for designing and implementing science and math courses and curriculum revisions. The goal of this component is to support faculty in exploring and introducing new and more effective methods of instruction in key courses that are taken by future teachers.

The third component of MASTEP, new teacher support, is instituted by the two state universities in the collaborative. All new science and math teachers are currently teamed up with experienced mentor teachers in the community.

The California Model for Teacher Certification and MASTEP

In California, a baccalaureate degree in an academic major is a prerequisite to earning an elementary or secondary teaching credential. Professional education preparation is deferred to a "fifth-year" credential program. As a result, during the undergraduate years, there is a separation of subject matter coursework from professional preparation. Traditionally there have been no teaching-oriented enrichment activities in future teachers' undergraduate background. Further, most science and math faculty have relegated instruction in pedagogy to their colleagues in science education and math education, who, in general, only impact students during the "fifth" year of credential coursework.

The MASTEP model concurs with the current reform movement as expressed by the AAAS [5] and the National Research Council [6] that it is the responsibility of science and math faculty to model how to teach their disciplines effectively. Since the majority of the students that enter the credential program spend their lower division years in community college introductory and core sequences, these courses are critical in setting the intellectual tone for future teachers. Traditionally, most teachers teach the way they were taught. Courses at the community college must be models of effective instruction, not only to better
serve the learning needs of the community college student, but also to provide models of instruction for future teachers.

Before a campus and faculty can achieve this goal they need to learn how students learn. The approach adopted by MASTEP and the collaborating colleges has been to devote the first two semesters of the project to workshops and seminars in teaching and learning before supporting faculty to undertake curriculum revisions. In addition to learning new modes of instruction and assessment, including the use of new technologies, the college faculty during this time period has formed course development teams that includes cross campus groups and K-12 participation.

The Role of the Community College in the Collaborative efforts of MASTEP

In the last two years, CSM has formally been involved in the MASTEP project with San Jose State University and San Francisco State University. The activities at CSM cover a number of aspects of the MASTEP model, including recruitment of future math and science teachers through an active future teachers' club; tutoring, mentoring and advising future teachers through the activities of an integrated science center; early field experiences for students through a science outreach program; and an extensive teaching and learning component that provides professional development workshops for science and math faculty resulting in their significant involvement in curriculum reform and the revision of core science and math courses.

The general goals of the College of San Mateo as a community college work synergistically with the goals of MASTEP. A major goal of CSM is to assist students to become self-regulated learners. To achieve this goal faculty have re-examined their teaching strategies in light of recent findings in learning. This re-examination has produced a shift of the teaching-learning paradigm. The new paradigm focuses on learners, holding them responsible for their learning and de-emphasizes the role of the teacher as the "dispenser of knowledge". The instructor assumes the role of "coordinating" and guiding the learning process. In this role, the instructor organizes group instruction, inquiry based laboratory investigations, collaborative learning experiences and offers to the learners resources that allow for different learning styles.
Assessment has also been re-examined. One major goal is to ascertain how well particular teaching strategies and technologies assist learners to acquire higher order skills such as the ability to communicate effectively, the ability to think critically and the ability to analyze data and synthesize new knowledge. Another major goal is to document the effect of the new teaching paradigm on the students' affective outcomes, such as willingness to participate in the learning process, preparedness to receive instruction, commitment to excellence, valuing and understanding the material learned, and using it with competence later when needed.

Reform of Content and Teaching
Revision of the Undergraduate Curriculum for Future Teachers

The Math and Science Division at College of San Mateo has been actively involved in curriculum reform for the past three years. Both math and science faculty have been introducing curriculum improvements directed at introducing new and more effective methods of instruction in key courses that are taken by future teachers. These efforts have been recognized by the local State universities and have resulted in a formal partnership for curriculum and professional development.

Current course areas at the College of San Mateo that are being revised through the MASTEP project include physics and general biology. The physics project entitled *Improving Math and Study Skills in Required Physics Sequences for Science Majors* will result in the creation of a preparatory physics course. The course development was prompted by the commonly high attrition rates and low student skill levels found in most physics courses, including those taken by future teachers. The faculty curriculum revision team not only includes three instructors from the College of San Mateo, but also the active participation of the physics department at San Francisco State University and San Francisco City College.

There is also a number of in-house funded reform initiatives related to the physics project. A project entitled *Integrating Computers into Physics, Astronomy, and Geology Laboratories* is a collaborative effort of an interdisciplinary team of physical science instructors to further supplement current teaching methods with multimedia and computer applications. This project is allowing student and faculty the use of technologies that apply the results of new learning theory research by creating opportunities for active investigation.
A second collaborative team that includes faculty from San Jose State University, CSM, and a local high school is involved in the development of multimedia modules for general biology. The modules will be used to supplement lectures for human biology and general biology courses at the lower division level. The goal is that through use of the modules, students will more readily comprehend abstract concepts in biology. The faculty development team has done extensive research and networking to ensure a strong pedagogical basis for the modules.

The College of San Mateo also has a math reform curriculum revision team. The team is in the process of redesigning curriculum and establishing a computer based mathematics classroom. In the Discovering Mathematics With In-Class Computers laboratory students use software actively and collaboratively to explore concepts as they occur in instruction, to perform arduous computations and to produce graphs and numerical tables quickly. Students work on real-world, open-ended problems, often collecting their own data. The intent is that students will view and practice mathematics as an experimental science in which concepts are established through a process of gathering data, building conjectures, then testing the conjectures. The classroom and curriculum has also been made available to high school mathematics instructors through professional development activities.

Another related educational reform initiative underway at CSM is the Geographic and Environmental Information for Education Project (GENIE). This project includes a development team of both faculty and students from mathematics, physical and life sciences, social and political sciences, statistics and urban planning. GENIE is actually a set of related projects that allows students real world, hands-on training in manipulating data acquired through remote-sensing techniques. Goals of the project include implementing remote-sensing data use in a broad range of community college courses, creating curriculum modules and courses that are transportable to other community colleges via the World Wide Web, and establishing a WWW server that will be an ongoing source of data and curriculum materials to other community colleges and universities. Teacher training materials related to the GENIE project will be developed through the collaborative efforts of CSM and the National Aeronautics and Space Administration (NASA) Office of Human Resources and Education.
Faculty Development Program

As these various curriculum revision projects continue their efforts, the curriculum development teams continue to attend conferences and workshops on teaching and learning in a continued effort to explore improved methodologies for teaching science and math. MASTEP sponsored workshops have included presentations by Dr. Bruce Alberts of the National Academy of Sciences, Dr. Marion Diamond, Director of the Lawrence Hall of Science, Dr. Roger Johnson of the Cooperative Learning Center of the University Minnesota, and representatives from Project 2061. Team members have also had the opportunity to attend one- to three-week workshops on multimedia development and technology mediated instruction. A number of faculty members have also attended residential summer workshops on various topics related to their projects. Through these efforts the College of San Mateo can better assure that future math and science teachers will experience models of effective curriculum and teaching.

Recruitment and Support of Future Teachers

Formation of a Future Teachers Club

As part of the recruitment and support effort for future teachers the College of San Mateo has formed a Future Teachers Club whose goal is to attract talented and diversified students into science and math teaching from the undergraduate pool at CSM. The club offers a number of benefits and activities for participants including field trips to informal educational institutions, tours to transferring universities, participation in model activities demonstrating effective teaching methods for grades K-12, assistance with the transfer and admission process into a four-year college, and assistance with scholarships, summer internships, and other financial opportunities to continue their education.

Opportunities for Early Field Experiences

Students are also given the opportunity for field experiences in K-12 classrooms through the Science Outreach Program. The College of San Mateo has an agreement with its "sister" elementary school that gives interested students the chance to work with the science resource specialist and elementary classroom teacher to design and present lessons in the elementary classroom. This component of the project has been supported by the Trustees’ Program
Support through the Integrated Science Center

Three years ago representatives from both the physical sciences and life sciences joined efforts to form the Integrated Science Center (ISC) at CSM. This center provides tutoring for students and is actively involved in curriculum revision projects that demonstrate the integrated nature of science and science teaching. Through the Center students who are interested in teaching are encouraged to work with faculty on curriculum improvement projects. The Center includes several high-end multimedia development stations that facilitate collaborative work by both faculty and students on developing multi-media instruction. This experience exposes future science and math teachers to emerging multi-media techniques in a very supportive environment. It also provides tutoring, personal support and academic advising for future teachers. The Future Teachers Club activities are also based in the Center.

Establishing an Educational Network

The MASTEP project at CSM emphasizes the formation of educational networks between K-12 teachers, industry and informal educational institutions in the Bay Area. A number of CSM math and science faculty serve on local K-12 curriculum committees. The College of San Mateo has hosted professional development activities and workshops for science and math faculty from local high schools.

Networking efforts are also taking place with Joint Ventures, a Silicon Valley Network which is a collaborative effort of local businesses, government entities, and K-12 schools to ensure that all students in the Silicon Valley attain world-class standards in literacy, mathematics, science, critical thinking and communication skills. Two school teams that are feeder schools to the college of San Mateo have been formed by Joint Ventures. Each team includes a high school and its feeder elementary schools. The Math/Science Division of the College of San Mateo is communicating with these school teams and looks forward to future collaborative efforts.
Evaluation

A major component of MASTEP is the continual evaluation of project activities to provide formative feedback to all persons involved in the various aspects of the project. The purpose of the evaluations is to determine the extent to which major goals of the project are achieved. Planning and implementation of specific evaluation procedures of project components funded by the National Science Foundation are directed by consultants from Far West Laboratory/WestEd in San Francisco.

The evaluation is focused along two lines of work: 1) a quantitative strand with data on specific indicators and 2) a qualitative strand consisting of case studies of the major components of the project. The following questions will be answered for the various project components that are being implemented at the community college level:

**Teaching and Learning Component**
- How have project activities impacted the practices of instructors of college entry-level math and science courses?
- Which project strategies are most successful in facilitating change in content and teaching of targeted college level math and science courses?
- What have participants learned that they value?
- What have participants learned that they can and do apply to their own instruction?

These questions are being answered by some of the following methods: interviews and surveys of students and instructors; faculty self-rating instruments and logs, attendance and participant feedback on project activities; documentation of changes to syllabi, classroom activities, and student assessment; and enrollment data on targeted courses.

**Recruitment Component**
- Is the MASTEP outreach program successful in recruiting increased numbers of potential math and science teachers, particularly among underrepresented minorities?
- How has the project impacted attitudes towards teaching as a career on the part of high school and college students?
- Which of the project strategies are the most successful for recruiting increased numbers of math and science teachers?

These questions are being answered by the following methods: attitude inventories,
enrollment data, demographic data, interviews with students and teachers, evaluation forms of specific project events/activities, and case studies.

Indicators of success for each component have also been identified. During the next three years the formative assessments of the project components will allow us to decide which components of MASTEP are successful enough to institutionalize. After this determination is made, the college will seek to reallocate internal resources and, where necessary, pursue external funding to continue those components that need to be retained but which are not currently receiving support directly from the college.

Through MASTEP, the Integrated Science Center, the Science Outreach Program and the Future Teachers Club, the College of San Mateo is taking a leadership position to make a lasting, dynamic impact on science and mathematics education in the Bay area.

References


[4] San Jose State University and San Francisco State University Perspectives, Student Census, Office of Institutional Research.


This paper describes the development of a two-course sequence in mathematics content for prospective elementary teachers. Community college and university personnel collaborated to develop a course sequence that would prepare prospective elementary teachers to teach mathematics with an understanding of concepts to support their abstract mathematical knowledge. The strategy was to begin with a broad vision and then focus on the smaller pieces which would achieve that vision. The course changes are validated by documents published by various educational and mathematical groups advocating an increased emphasis on teaching for understanding rather than rote learning. Significant change is difficult without support from colleagues and sufficient time, both necessary to the change process. The noteworthy components of Austin Community College's revised course are a safe environment in which students become independent learners and written communication as an integral part of the course resulting in students who have increased their conceptual understanding. As a result of taking the course, students accept responsibility for their own learning, have increased self-confidence, and show enthusiasm for mathematics. While requiring a major commitment from faculty, the results are well worth the effort.

"Any fool can know. The point is to understand."
- Albert Einstein

History of the Program

Austin Community College has a long history of involvement with the mathematics preparation of future elementary school teachers dating back to at least 1977, four years after the college was established. The college's six-semester-hour, two-course sequence has always transferred to the University of Texas at Austin because instructors at both institutions are aware of each other's activities. For a community college, our current and cumulative experience in this area is very large.

This association with the university was strengthened when, in 1994, the current vision, philosophy, and structure of our two-course sequence was developed in collaboration with university personnel. Mary Hannigan and Tracy Rusch received funding to develop a content course that would better serve prospective elementary teachers. This curriculum effort was shared with other interested instructors from both institutions during all stages of development. Vera Preston was one of the earliest advocates of this new structure, as it
complemented her personal vision, and added her expertise to subsequent revisions. Support for this new vision of preparing teachers continued to increase among ACC faculty and is now accepted college-wide.

Educational Philosophy

A democracy can survive only with an educated populace. Any culture is only a generation from anarchy. The education of our children is essential; therefore, the education of the teachers of our children is critically important to all of us. It is in the selfish best interests of all citizens to educate our children. American Indian leaders consider the next seven generations when they make decisions for their people. The rest of the United States could benefit as a people if our leaders considered how their decisions would affect the people one hundred forty years from now.

The process of teaching mathematics and learning mathematics is iterative: the way preservice elementary teachers are taught influences their understanding of and beliefs about mathematics; their understanding of and beliefs about mathematics influence the way they teach; and the way they teach influences their students' understanding of and beliefs about mathematics [1].

If college professors are sensitive to the variety of learning styles of their students and help students become aware of their own learning styles, it is likely that the students will carry that sensitivity with them into their own classrooms. Providing the students with a foundation of concepts to support their abstract mathematical knowledge will also go with them and will benefit future generations. Creating a classroom environment that addresses these issues is a college professor's contribution to breaking the cycle of mathematically ill-prepared elementary teachers.

Vera Preston's interest in preparing prospective elementary teachers began when asked by the child of a migrant worker to explain division. Her secondary mathematics preparation had only prepared her to teach the algorithm, rather than the concept. This prompted her to enroll in courses that prepared her to teach elementary mathematics, which she could later share with her college students. Her teaching strategies have evolved over the years to adapt to the needs of her students.
Mary Hannigan's experiences began in a similar way with a class of rural seventh-graders who needed a conceptual foundation that Mary's secondary mathematics program had not prepared her to provide them. She took graduate courses in elementary methods and began attending conferences to help her determine how to better serve her college students so they would not end up in the same predicament she had. Serving as a mentor to a new fourth-grade mathematics teacher, her mother, helped define for her the needs of beginning elementary teachers.

Course Development

As part of her graduate studies at the University of Texas, Mary, with colleagues Tracy Rusch and Susan Hull, was given the opportunity to rethink the needs of prospective elementary teachers. In the summer of 1994, Mary and Tracy received funding to rewrite the curriculum for this course which both would teach during the fall term, Mary at ACC and Tracy at the university. Soon after, these newly developed curriculum materials were shared with Vera. Working in isolation, Vera had made some changes to her course, but it is challenging to make such drastic changes on your own. With a support network in place, ACC's course for prospective elementary teachers began a coordinated evolution.

Revisions to the curriculum are ongoing. While Mary and Vera share ideas and materials, based on the same philosophy, each has her own "style", of course. These materials were shared at a workshop with other faculty who had expressed an interest in their work. As a result of this workshop, the vision of this course shared by Mary, Vera, and Tracy has been adopted college-wide.

The changes in the course are influenced by personal experiences and are validated by documents published by the National Council of Teachers of Mathematics (NCTM), the Mathematical Association of America (MAA), the American Mathematical Association of Two-Year Colleges (AMATYC), and the Texas Statewide Systemic Initiative (Texas SSI) [1-5]. Vera was involved, as president of Women and Mathematics Education, in developing the Curriculum and Evaluation Standards for School Mathematics [2]. As a member of the Action Team on Strengthening the Mathematical Preparation of Elementary Teachers of the Texas SSI, Mary co-authored a survey sent to college of education deans and mathematics department chairs which showed a lack of community college participation in the preparation
of prospective elementary teachers [6]. Austin Community College's long involvement with this course as well as the current efforts in curriculum revision indicate that ACC is a state leader in preparing future elementary teachers.

As part of her involvement with the Texas SSI, Mary visited universities in the state which were funded by the Texas SSI to improve their courses for prospective elementary teachers. Observing other faculty making changes to their courses which were similar to the ones made at ACC, confirmed for her that ACC's vision was shared by others across the state.

**Observations on the Process of Change**

It is important to understand that the significant changes that occurred in Austin Community College's course for prospective elementary teachers took time, energy, and thought and was a collective effort on the part of many people. It was by no means a "quick fix"; it was an incredibly challenging endeavor.

ACC's course has been evolving since 1994 and continues to evolve. Every instructor who teaches the course is always searching for new projects and activities that are mathematically powerful and will develop and/or deepen students' understanding of mathematics. Quality resources for this college population are not readily accessible, so this is not an easy task.

The strategy of beginning with a broad vision and then focusing on the smaller pieces worked well for ACC. Within the scope of the philosophy, there is much room for individual creativity on the part of the instructor. While the vision remains relatively constant, the pieces are adjusted to fit the interests and needs of a specific class.

Working together to make changes is essential. Vera, working alone, had many frustrations with the course she was developing; there just weren't enough hours in the day to make drastic changes. Conversely, Mary and Tracy, while still frustrated implementing change, had each other to share the creative load, the triumphs and failures. Having a support group, even if small, is essential to successful implementation of a new course.
Effects of Change on the Students

Prospective elementary teachers are often highly anxious about mathematics and, to varying degrees, believe that they already know all the mathematics necessary to teach elementary school. ACC's course generally changes those ideas. Most students complete the course with more confidence in their ability to do (50% of students completing an end-of-course survey agreed that elements of the course helped them develop confidence in their problem solving skills, 41% strongly agreed) and understand mathematics (83% agree or strongly agreed) and realize that there is more to mathematics than regurgitating information.

Students' increased confidence in their mathematical ability (83% of students reported a very low to moderate level of confidence at the beginning of the course, 78% reported a high or very high level of confidence upon completing the course), hopefully increases their confidence in their ability to explain mathematics to their future students. At the beginning of the semester many of these students express concern that they will perpetuate the math anxiety they have experienced. By the end of the course, they are convinced that this will not happen, and they haven't even had a course in the methods of teaching elementary mathematics! The students' have realized that they know more mathematics than they believed they knew and can explain it to others.

The excitement at seeing the growth these students display—improving conceptual understanding, showing enthusiasm for mathematics, accepting responsibility for their own learning, in addition to increasing self-confidence—more than makes up for the difficulties involved in making changes and managing this labor-intensive course. It is the most gratifying and important course the authors teach.

A Vision for the Future

Our efforts are driven by the commitment to provide future generations with elementary teachers

- who are confident in their ability to do and to learn mathematics
- who have well-developed mathematical analysis skills which they use readily and routinely
- who have a deep understanding of the mathematical ideas they share with their students
who are able to thoughtfully select mathematical learning experiences and clearly explain mathematical ideas

- who embrace the opportunity to share the magic, beauty, and fun of mathematics with children [7].

This vision guides the curriculum and environment of the mathematics content course for prospective elementary teachers at Austin Community College. The remainder of this article describes the underlying structure of the course sequence by highlighting the strengths of the course.

"Those who can, do. Those who understand, teach."

- Lee Shulman [8]

Students develop an understanding of concepts, not just an ability to use algorithms. Projects are an integral part of the course intended to build students' conceptual understanding of mathematics. While students are encouraged to work together on the projects, the projects can be completed individually. Many of the projects utilize manipulatives to develop a conceptual foundation on which to build a bridge to abstraction.

Another component of the course, challenge problems, requires the students to justify to a peer the solution of the problem. In writing this justification, the students develop an explicit understanding of the mathematics [9]. They are instructed that this paper is not to be the steps of their solution process.

A challenge problem is a problem that requires more than simply applying a process in order to solve it. Challenge problems can generally be solved by a variety of problem solving strategies—pictorially, numerically, or using more sophisticated computational procedures. As long as the solution is justified, any method of solution is acceptable. The classic handshake problem (How many handshakes are made between eight people if everyone shakes hands with everyone else exactly once?) is an often used challenge problem in the patterns unit.
"Tell me, and I forget;  
Show me, and I remember;  
Involve me, and I understand."  
- Ancient Chinese saying

Students participate in a mathematical community which requires that they clearly communicate mathematical ideas and work together to model concepts. By working on the projects cooperatively, students are provided the opportunity to develop their skills in mathematical communication. Using tools (manipulatives) to model concepts requires that the student share a common language.

Participation in a mathematical community develops skills in the practice of mathematics. Mathematical inquiry or the practice of mathematics has long been the exclusive domain of mathematicians; in the desire to impart mathematical information, they have often slighted many students by not providing them the opportunity to discover the joys of mathematical inquiry. ACC's course has attempted to facilitate this experience for prospective teachers so that they will one day provide it for their own students.

An additional benefit that results from participating in a mathematical community is that students recognize the different learning styles that exist. In discussing problems they are confronted with the various ways that people think about mathematics. The end result of that thinking is the same, but the path to that end can be very different. Recognizing and accepting these differences will benefit them when considering how to present a lesson to their own future students.

"They know enough who know how to learn."  
- Henry Adams (1838 - 1918)

Instructors establish a safe environment in which students become independent learners. To develop the skills of communication and mathematical inquiry, math anxious students must feel safe enough to take risks or make mistakes or "contribute ideas for investigation or discussion" [1]. Once they are secure in the knowledge they will not be denigrated for "not knowing", they will be willing to take greater risks to achieve greater understanding. This safe environment doesn't just happen, instructors must make a conscious effort to foster this environment. This is not an easy task, but one well worth the effort required.
Teachers must be flexible and able to adapt to ever-changing curriculum. New, unfamiliar content may be added to the curriculum or a new course must be prepared that hasn't been reviewed recently. To adequately prepare to teach, instructors must be able to "teach" themselves this material. New teachers spend an inordinate amount of their preparation time trying, sometimes unsuccessfully, to teach themselves the mathematics rather than developing engaging, mathematically rich lessons [10]. As a result, they resort to telling students how "to do" mathematics rather than teaching concepts [11]. Prospective teachers who have experience "teaching themselves" and have developed confidence that they can adequately prepare themselves to teach mathematics are in a better position when they begin their career. ACC's course attempts to develop independent learners, students who have both the ability and confidence to teach themselves.

"How do I know what I think until I see what I say."
- E. M. Forster

Written communication is an integral part of the course. Many of the course components require the students to communicate mathematical ideas in writing. Questions on projects require a justification for the solution; challenge problems are entirely a justification of the solution to a problem. Focus questions, another written component of the course, require students to describe connections among mathematical ideas and relate those ideas to other disciplines and to life; the focus question for the sorting and classifying unit asks "All of the projects in this unit focus on characteristics (or "attributes") and on the development of organizational strategies. These two concepts are essential, fundamental elements in the study of mathematics. Why?". To support the argument presented, the students present examples drawn from mathematics as well as other areas. While not a technical paper, a good focus question will show evidence of significant reflection upon mathematical ideas.

In addition, students also write essays which reflect on their feelings, beliefs and emotions regarding the course and their mathematical growth. These types of essays are found as summaries of the various units, as part of a portfolio assignment, or exist independently as a cumulative end-of-semester assignment. Students are provided with guidelines for the assignment and then allowed the freedom to sculpt the paper to reflect their mathematical knowledge.
Final exams are also an extensive writing assignment. The goal of the final exam, generally a take-home exam, is to allow students to demonstrate their ability to learn independently. The questions posed are mini-challenge problems or challenge problem/focus question hybrids, but not ideas specifically covered during the course of the term. Thus students are required to utilize resources other than the instructor to justify a problem solution or make connections among mathematical ideas.

Written communication is an important aspect of the course. This emphasis is due to the lack of time available to evaluate oral communication, as in student presentations. If the students can effectively communicate through written language, they surely can communicate effectively through the spoken word.

Conclusion

For colleges considering a revision of an existing course or developing a new course for prospective teachers there are many issues that must be considered. There is no one blueprint for this endeavor. Faculty needs ample time to consider the objectives of the program, the needs of the students, and the needs of the faculty.

The success—based on the comments of students, methods faculty at the local universities, and local public-school administrators—of Austin Community College's program for prospective teachers lies, in part, with the quality time spent discussing the goals and objectives of the course and the means to achieve those goals. Included in the discussions were a description of the typical student exiting the program, the mathematical skills and understanding they possess, and their level of preparation for subsequent courses, in this case the university methods course. The opportunity to have meaningful conversations on these topics was made possible by funding and the support of the institution. Developing a course of this nature is not a "spare time" task.

Once the underlying structure of the course is established (a commitment to a strong writing component, the vision of the environment, etc.), the pieces that pull the whole course together must be located; in ACC's case, the problems to use as challenge problems, the focus questions, and the individual projects. At this point, there may be minor differences among instructors as to the best vehicles to achieve the objectives, but that is what gives all
participants ownership in the course.

The actual curriculum materials that evolve or are located need to be compatible with an institution's vision for this course. The key consideration is that the activities must facilitate the mathematical growth of the students. The selected materials must be appropriate for the students, at their current level of mathematical sophistication, and that then take them beyond that level, striving for mastery of appropriate mathematical content.

Assuming that it would be desirable for U.S. teachers to have better mastery of their subject matter, it not obvious that the simple step of requiring more mathematics courses for future teachers will achieve this goal. Standard undergraduate courses do not dwell heavily on the relevance of their subject matter to the...curriculum, and teacher candidates may not be able to make the connections on their own [12].

The advantage of ACC's course for prospective elementary teachers is that it DOES provide the students with opportunities to make the connections between the mathematics they have studied and elementary school mathematics. The faculty believe that the current course is NOT just more mathematics, but better, more appropriate mathematics which prepares them to teach the next generation of students.

This course requires a major commitment from the faculty who teach it. But despite the additional workload, we are impressed by the changes we see in our students. Their mathematical sophistication and their self-confidence increase dramatically. Because of the preparation we provide, we believe we significantly impact future generations of elementary schoolchildren which makes the effort worthwhile.

References


THE COMMUNITY COLLEGE OF PHILADELPHIA: EDUCATING
TEACHERS FOR A CHANGING WORLD

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Program Overview

The Community College of Philadelphia is currently in the fourth year of the
Collaborative for Excellence in Teacher Preparation (CETP) project supported by the
National Science Foundation. The Community College of Philadelphia is a two-year, urban,
comprehensive community college that provides accessible, low-cost education for an
extremely diverse population of city residents. The CETP partnership with Temple University
and the Philadelphia School System has created a model for K-12 teachers' education which
integrates new inquiry-intensive and technology-based pedagogy with mathematics and science
core content courses. In keeping with the spirit of this grant, the College has created and
implemented science and math courses primarily for pre-service teachers that provides
exemplary models of teaching that reflect current research. These new courses emphasize a
learning paradigm rather than a teaching paradigm. As such, the focus is on the learner and
the learning environment. Expectations for student success are high. Students engage in
individual and collaborative inquiry in an environment that expects and demands critical
thinking. Although initially designed for pre-service instructors, we have found that all
students benefit from these courses.

In order to promote student learning and preparation for careers in teaching, three courses
at the Community College of Philadelphia were specifically targeted for change. Faculty
involvement has been high from the beginning and continues to be a key factor in the success
of these courses. As a result of these changes, other courses offered have also created or
revised. In all, seven new or revised courses have been created and fully institutionalized. In
addition, specific articulation agreements have been fostered with numerous four-year
institutions in the area as these courses have proved to be extremely beneficial to the
preparation of both pre-service teachers and to other majors. The courses that have been
developed and implemented include: General Biology I (Biology 106), General Biology II

(Biology 107), Inquiry into Chemistry (Chemistry 105 and Chemistry 106), Mathematical Models I (Math 155) and Science, Technology and Society (STS 101 and STS 102). Institutionalization of these courses has occurred, and the courses have become the most highly recommended courses for education majors at the college.

**Course Descriptions**

General Biology I is a non-science majors course that was proposed, created, and implemented by a committee of interested faculty. This new course listing and subsequent advising of students has led to increased enrollment in the course. Currently, there are thirty-two sections with twenty-six students each. Three of the sections are specifically designated for education majors. The new course outline and syllabi contain seven discovery questions with student outcomes or standards accompanying each. These have been based on the science and biology standards contained in the AAAS Benchmarks [I] and the National Science Standards [2]. In addition, the course has been based on the recommendations of the National Association of Biology Teachers. The major themes of the course center on cell biology, genetics, evolution, and ecology. This inquiry based course includes laboratory experiences and activities that emphasize science process skills. This semester (Fall, 1997), nine of the classes offered are taught in the Biology Computer Studio. Two of these are especially designated for education majors. The Biology Computer Studio is a multi-media classroom equipped with twenty-six computers. Each computer has over fifty software simulations and experiments and has internet capabilities. The studio also is a wet lab equipped with water, gas, and lab work space. The studio approach to biology adheres to the premise that students learn when they are actively involved. The classroom allows for both computer and wet labs, access to the internet, small and large group interactions, and enhanced lecture/discussion through multi-media. Through a partnership with Prentice Hall, the College has been designated as a Beta site for the new "Life on Earth" biology internet guide that accompanies the course textbook. We have provided important editorial feedback to the creator and keeper of this much used web site. For the more traditional classrooms, instructors are using cooperative learning, minds-on problem solving activities, and enhanced lecture/discussion using technology. Several alternative methods of evaluation are currently being utilized by instructors of General Biology I. Assessment emphasizes the skills and processes as well as the content examined in the course. Problem solving, case study analysis, critical thinking skills, journals, written and oral reports, and portfolios are some of the
alternative forms of assessment utilized by various instructors. Due to the popularity of this course, General Biology II was created and designed as a follow up course. It emphasizes a problem solving and case based approach to comparative anatomy and physiology in a laboratory setting. Several sections are currently using the Biology computer studio.

Because many pre-service teachers elect to enroll in Biology, emphasis has been placed on the changing pedagogy in this area. The goal is to provide an excellent model of science instruction. However, Mathematical Models I has also been developed specifically for pre-service teachers. It is offered as an alternative to traditional math courses and was developed collaboratively with faculty from Temple University and the Community College of Philadelphia. The emphasis is on problem solving using an inquiry based approach to education with extensive use of graphing calculators. Mathematical topics are at a freshman level and may cover topics selected from algebra, probability, plane geometry, counting, financial analysis, and trigonometry.

Another course created and implemented with the support of the CBTP is Inquiry Into Chemistry. It, too, is offered as a lab based science course for pre-service teachers and non-science majors. The course emphasizes a discovery approach in which students learn to interpret laboratory observations in the manner of a real world scientist. The experiments are less prescribed and more open to interpretation with the goal of appreciating chemistry more as a rational field of inquiry than as a fixed set of rules.

A new inter-disciplinary course, Science, Technology, and Society, was developed by a committee of members of the Biology, Chemistry and Engineering departments of the Community College of Philadelphia. The course was proposed and subsequently approved January, 1995 as STS 101. The course utilizes theme based investigations that are conducted using the technology in the studio lab as well as field trips and guest speakers. The course was offered over the summer to high school students involved in the Tech Prep program. The course was also offered during the Fall 1997 semester and is currently being offered for the spring semester of 1998. This course has been specifically designed for both non-majors as well as for students involved in the Culture, Science, and Technology program.

There have been several changes in the teacher preparation requirements for elementary
teachers at the Community College of Philadelphia. Two courses in Education form the core of Education offerings at Community College of Philadelphia. These include Education 201: Introduction to Education and Education 225: Educational Psychology. These courses, developed many years ago, promote and model pedagogy consistent with CETP philosophy. This pedagogy supports an inquiry based philosophy which is reflected in both reading materials and in class activities. The CETP project has stimulated further activities which encourage development of critical thinking abilities in students through cooperative learning methods. Active learning is encouraged in these courses.

The analysis of case studies is an important technique for use in education courses. Many situations occur in classrooms that can provide pre-service teachers with insight into classroom management, teaching and learning opportunities for special education children, and faculty-student relationships. By exposing students to these important issues and having them work through them, they are able to understand different problem-solving approaches. In this way students begin to understand how scientists go about solving problems in their work. The model of a scientist collecting data is likened to teaching where observations and other data help to make decisions regarding practice.

Students' readings in both Introduction to Education and Educational Psychology reflect CETP philosophy and practice. When students learn about Piaget, Vygotsky, Montessori, and Dewey, they not only read the words of these educational philosophers, but also they engage in hands-on activities to understand and appreciate their work. In addition, some reading materials from the CETP psychology course at Temple University are being incorporated into the Educational Psychology course. Material relating to mastery motivation and gender issues in math and science education have been added to the syllabus. It is our belief that the modeling of hands-on activities suggested by some of these readings is a strategy which will become part of Community College of Philadelphia students' repertoires of behavior to be practiced when these students enter the classroom in professional roles.

Though not officially part of the CETP project, Education 202 was developed and was offered by the College for the first time in Spring 1997. Education 202: Introduction to the Foundation of Education Field Experience, gives students of education the opportunity to do direct observations in a school setting. This field experience using participant-observational
strategies encourages students to become critical educational researchers. Students will formulate hypotheses about the teaching-learning process as classroom dynamics and interactions are observed and analyzed. By noting interactions between pupils and teachers in terms of who initiates talk, who participates in discussion, and what kind of classroom climate is fostered, students will get information about the expectations each brings to the process, what happens in the classroom, and how the teacher and learner change under certain circumstances. This activity can generate relevant questions about specific features of a classroom experience. Classroom observations followed by weekly group class discussions will help the students begin to understand the complexity of classroom dynamics. In classroom settings, students not only observe classes in action, but also they work with students in small groups, helping them with reading, math, and other projects. In weekly seminars at Community College, students discuss different aspects of classroom life such as instructional strategies, activities and motivation, evaluation strategies, and staff and parents as part of the school culture.

In addition to these Education courses at Community College of Philadelphia, students in the Education Curriculum follow a program which includes liberal arts courses such as math and science courses. Math 155, Biology 106, Biology 107 and Chemistry 105/106, courses developed in conjunction with the CETP grant, have been included in the Education curriculum and students are encouraged to take them. The pedagogy offered in these courses is supported by Education faculty at Community College who hope to recruit more students for these excellent courses.

Student Recruitment and Retention

During the Spring 1997 semester the Philadelphia CETP offered a seminar for education students at the Community College. This well-attended seminar severed two purposes. The first objective was to provide students with a forum to discuss the following issues: multicultural settings, principles of cooperative learning, methods in science and math instruction, use of technology, and, career planning. Secondly, students were given information on each of the CETP courses and, they were able to get information on the education program at Temple University. Many students transfer to Temple University and through the grant we have assured students a smooth articulation with Temple University. Students will continue to see the CETP philosophy in both content and methods courses at Temple University; the
seminar provided us with a platform to promote this arrangement. We are planning to offer this seminar each year.

Another exciting dimension of the CETP grant has been the dissemination of yearly scholarships for promising pre-service teachers at the Community College. In 1996 we awarded seven scholarships, while in 1997 there were thirteen, and eleven in 1998. These applicants must demonstrate their commitment to their field through experience, grade point average and written expression.

To further promote the CETP courses, we found it imperative that academic advisors and counselors be properly informed. The principle investigator of the grant along with several faculty members have had meetings and classroom demonstrations with counselors to insure that they are well informed so that they can help students make the right choices. Our foresight in this matter has led to increased enrollment and retention in the CETP developed courses.

Students preferentially enroll and stay in courses they know will transfer to other colleges. The department heads along with the education coordinator have worked very hard to insure articulation agreements with Temple University as well as numerous other area colleges and universities concerning the CETP developed courses. Many Community College education majors take their content courses at the Community College and their methods courses at Temple University. Collaboration with Temple University has increased retention and participation of a diverse population of pre-service teachers. The majority of these students go on to teach in the Philadelphia Public School System.

Staff Development

Staff development has been key to the creation and continued success of the CETP developed courses. Working with Temple University faculty has led to the development of parallel courses at Temple and the Community College as well as to articulation agreements between the institutions.

Staff development at the Community College has included enhanced committee involvement and extended time opportunities. Initially, the challenge was to involve faculty
in the development process. Extended time opportunities enticed faculty to participate in the creation and implementation of new and revised courses. Members of this group during the 1995-96 academic year were involved in course revisions and development of course syllabi, laboratory experiences, class activities, and assessment. During the 1996-97 academic year, extended time was granted to those individuals interested in developing classroom strategies that utilized technology and software purchased. In addition, there were weekly meetings conducted for instructors of new courses; participation in this was voluntary and well attended.

Staff development has also included several initiatives. The first was to increase the working members of the committee for General Biology I. The second was to offer extended time as a way to increase participation in this group for the academic year 1996-97. Third, faculty were offered extended time to learn technology. Specifically, faculty were required to prepare a lesson/activity that utilized multi-media. Over fifteen different faculty members successfully participated in these projects. Fourth, on-going support to learn technology and new pedagogical practices is provided in small groups and one on one through the Biology Computer Studio. This service is made available by providing extended time for a faculty position to specifically function in staff development. Through these processes faculty are using technology and are coming together frequently to discuss successful strategies and activities. As a result, instructors of other biology courses are beginning to change the way they teach. Many of the activities and labs created through these projects are now available to other instructors as a result of a shared faculty computer room. To foster the institutionalization of continued improvement in teaching, the department has allotted for extended time for one staff person to serve as a coordinator in this area.

Outcomes

The success of the students in these classes has been well documented by both qualitative and quantitative measures. Student retention is higher than in more traditional classes, and students in CETP courses have outscored their peers in traditional courses on pre and post test assessments. Most importantly, their attitudes towards science and math, and science and math courses, has become more positive.

The General Biology I committee developed a pre and post test to measure differences in
courses taught traditionally versus those that were focusing on the learner and the learning environment (CETP courses). This test was piloted in the Spring of 1996. Several modifications were made and the pre-test was given to all sections Fall, 1996. The post-test was given during final exams in December, 1996. Overall, the results suggest that those students in the traditionally taught classes do not do as well as those in classes that are less traditional. Students in the CETP sections averaged 68% on the post test while students in the traditional classes averaged 52%. The pre-test average for both groups was 52%. The test consisted of sixty items that covered the entire course. Emphasis was placed equally on content and process skills. Item analysis revealed that students in CETP courses outscored their peers on content questions but, they significantly outscored their peers on the problem solving and analysis questions. Sample questions and results are shown on Figure 1. The testing instrument was used for one other semester and similar results were obtained. Further changes and refinements are being made and it is hoped that a new pre/post test will be administered in the 1998-99 academic year.

Students attitudes towards the courses are routinely monitored each semester through the internal evaluator for the CETP. Table 1 shows students attitudes in Biology courses. Seven of these sections are CETP and considered the new model while two of the sections were the same course but taught more traditionally. Overall, the students in the CETP sections clearly find their course more useful, interesting, and, likable. Table 2 shows the same survey given to two sections of math courses. One course is the revised CETP class while the other course offers the same material but the pedagogy is more traditional. Again, the CETP section was seen more favorable by students. This data represents only one semester but, it is typical of data collected from 1996 to the present.

Student focus groups conducted yearly by the internal investigators have revealed a similar pattern as the surveys. In addition, students generally achieved higher grades in CETP courses.

Milestones and Dissemination

Overall, the successful model that we have created contains the following accomplishments. We have:

• redesigned the content and pedagogy of selected core courses: at the Community College
of Philadelphia we have redesigned or created six courses. These include: Biology 106, 107, STS 101, Chemistry 105, 106, and Math 155. In addition, other biology courses have been influenced by the CETP. These include Biology 109, 110 and 241. Instructors have adopted new practices in both the learning environment and in evaluation. Parallel courses have been designed at Temple for both Math 155 and Biology 106. Articulation agreements have been made with Temple and other area four year institutions. Emphasis for new and revised science courses has been on the processes of science and math rather than covering vast amounts of content. There are a variety of instructional strategies utilized and students have many opportunities to discuss and explain in a cooperative, problem solving environment.

- developed a new, team-taught cross-disciplinary science course: STS 101 has been created and offered as a cross disciplinary course. A committee of instructors from across the disciplines created the course. The course ran in SS I, Fall 1997 and is currently being run (spring 1998). A follow up course (STS 102) is currently being created by a committee of four faculty. It is anticipated that this course will be offered for the Fall 1998 semester.

- given a series of staff development workshops and seminars: at the Community College we have offered staff development every semester that the grant has been funded. Currently, staff are offered extended time to create new materials. There are also specific times that faculty can come to the studio on a drop in basis to learn specific uses of hardware and software. CCP has also offered seminars for area secondary schools and has offered seminars for other educators and for pre-service teachers.

- expanded programs to attract and retain minority students: CCP works closely with the E=mc² and AMP programs.

- have fostered institutional ties with the following grants/programs within the college: Culture, Science, Technology grant; Alliance for Minority Participation grant.

- formed linkages with faculty from the Community College of Philadelphia and other area community colleges. Using the pedagogical reforms embraced by the CETP, instructors
are developing, implementing and evaluating a new laboratory manual in biology.

- collaborated with Prentice Hall on improving their web sites and their textbooks.

- worked with Prentice Hall in publishing lab manuals for the various courses offered.

- have and are working with Logal software as a beta site for the new internet version of Logal Biology - a week long seminar will be offered this summer for area participants to learn to use the software.

- hosted on February 5 and 6, 1997 a hands on Inquiry-based Biology workshop that was attended by many local college and university administrators and professors.

- hosted (April 12, 1997) a seminar for CCP education students that focused on teaching practices, technology, cooperative learning, teaching in diverse environments, courses for education majors at CCP, and transfer issues.

- created a Biology department web site with links to all of the courses taught, the instructors, and course outlines/syllabi. There are special hyperlinks for the CETP and the Biology Computer Studio. The URL for this site is: http://www.voicenet.com/~bluesky/ccpbiology.html

- institutionalized all of the CETP courses (Biology 106, 107, Chemistry 105, 106, Math 155, STS 101).

Conclusion

What sets this program apart from other initiatives is the broad based support for and commitment to change. One of the main recommendations of the National Research Council is that "all students should have access to supportive, excellent programs in science, mathematics, engineering, and technology, and all students should acquire literacy in these subject by direct experience with the methods and processes of inquiry" [3]. The grant has ensured that this occurs for all students, but it has concentrated on pre-service teachers. The
Community College now plays an important role in the education of future teachers of the Philadelphia School System. The inter- and intra-institutional ties are in place and will remain so long after the grant money is gone. We have made a commitment to continuous improvement in the hope that this spirit is transferred to our future K-12 teachers.

The overall consensus is that the CETP is achieving its objectives. The National Science Foundation has recognized the curricular and pedagogical improvements that have been made. These improvements are summarized in the Shaping the Future report submitted as a review on undergraduate education [4]. As education majors at the Community College of Philadelphia transfer to Temple the will receive quality core courses as well as revised methods courses. Eventually, those students who have participated in multiple CETP courses will be tagged by the Philadelphia School System for placement at schools where they can most affect change. It is our hope that these teachers will enter their professional experience and mentor the type of teaching modeled by the instructors of their CETP courses.
Sample Question:
DNA is the material of heredity because it:
(a) stores genetic information
(b) replicates
(c) controls the cell's activities
(d) all of these

Correct response: D
Level: content question or recall
CETP groups (N=10 classes, 188 students) 68% answered item correctly
Traditional group (N=11 classes, 176 students) 39% answered item correctly

Sample Question:
The following graph shows the relationship of plant growth to light intensity.

[Diagram showing a peak in plant growth as light intensity increases, then decreases]

Which illustrates the relationship between light intensity and plant growth?
(a) as light intensity increases, plant growth increases
(b) as plant growth increases, light intensity increases to a point and then decreases
(c) as light intensity increases, plant growth increases to a point and then decreases
(d) as plant growth increases, light intensity increases

Correct response C
Level: interpretation/analysis
CETP groups (N=10 classes, 188 students) 83% answered item correctly
Traditional group (N=11 classes, 176 students) 53% answered item correctly

Sample Question:
A class wants to find out if temperature has an effect on the growth of bread mold. The mold is grown in nine identical petri dishes containing the same type and quantity of nutrients. Three containers are kept at 0° Celsius, three containers are kept at room temperature, and three containers are kept at 25° Celsius. The containers are examined and the growth of the bread mold recorded at the end of four days.

The independent variable is the:
(a) temperature of the containers
(b) amount of nutrient in each container
(c) growth of bread mold
(d) number of containers at each temperature

Correct response A
Level: application
CETP groups (N=10 classes, 188 students) 71% answered item correctly
Traditional group (N=11 classes, 176 students) 45% answered item correctly

(These three items all fell within acceptable discrimination limits of .25 - .75)
Table 1. Science and Mathematics Course Survey: CCP biology course

<table>
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</table>

R = CETP revised course  T = course taught in traditional method
Items are scored: 5 = strongly agree through 1 = strongly disagree. Scoring of items 2, 5, 7, 10, 15, and 20 was reversed. Items 1-21 averaged to form scale score.
Table 2. Science and Mathematics Course Survey: CCP math course

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</table>

R = CETP revised course  T= course taught in traditional method
Items are scored: 5=strongly agree through 1=strongly disagree. Scoring of items 2,5,7,10,15, and 20 was reversed. Items 1-21 averaged to form scale score.
References


COLLABORATIVE EFFORTS TO ENHANCE AND STRENGTHEN
TEACHER TRAINING IN MATHEMATICS AND SCIENCE

G. TURBEVILLE and D. JOVANOVICH
J. Sargeant Reynolds Community College, Richmond, VA 23285-5622

J. Sargeant Reynolds Community College (Reynolds) has a rich history sponsoring and being involved in a variety of activities focusing on the preparation of K-12 teachers. Described in this article are the different collaborations that Reynolds faculty initiated or in which they participated. Mathematics and science course content was first highlighted through collaboration with discipline faculty at nearby Virginia Commonwealth University (VCU). More recently there was intense participation with several other two-year and four-year colleges in a National Science Foundation (NSF) funded urban collaborative grant, extending for five years. This collaborative will soon begin the third year of its enterprises. In addition, Reynolds faculty received funding and provided several highly successful Eisenhower professional development activities for in-service teachers. The authors are faculty members at J. Sargeant Reynolds Community College and are writing on behalf of the collective efforts of about 15 faculty members from that institution. Both Ms. Jovanovich and Ms. Turbeville have been actively involved in many of the efforts described below, helping Reynolds become the most active community college in Virginia’s collaboratives for teacher preparation.

Through these courses and collaborative efforts, Reynolds hopes to enrich the training of in-service and pre-service teachers and to broaden teachers’ bases of knowledge in these disciplines. Reynolds faculty recognizes that many in-service teachers are insecure in their understanding of and ability to convey knowledge of mathematics and science. This training will provide future students with more enthusiastic teachers and hence better training for the students in math and the sciences. Furthermore, these more enthusiastic role models may help recruit future teachers.

Liberal Arts Mathematics Course
On its three campuses, Reynolds serves a diverse student body of more than 15,000 students annually from nearby urban, suburban, and rural areas. More than 30% of
Reynolds' student body is composed of minorities who are traditionally underrepresented in mathematics and science. More than 75% of the college transfer students enrolled at Reynolds plan to transfer to VCU, which is within three miles of Reynolds. In a collaboration which began about six years ago, Ms. Turbeville together with a VCU professor developed and piloted a new contemporary mathematics course for liberal arts students, many of whom are prospective elementary school teachers. Topics covered in the course include polling methods, networks, fair division, voting, and population growth.

The two instructors used team teaching to develop and present the innovative course, which included writing assignments and group project components and alternative assessment techniques. Because both instructors were concerned that any negative attitudes about mathematics of future teachers might be transferred to their future classrooms, developing an improved attitude toward mathematics was a key emphasis for the course.

VCU currently offers this course to all liberal arts majors, including elementary education and non-mathematics and non-science secondary education majors. The course is in place at Reynolds and students completing the course may successfully transfer the credits to VCU.

Virginia Collaborative for Excellence in the Preparation of Teachers (VCEPT) Participation

As a direct result of the successful collaboration for the contemporary mathematics course described above, Reynolds and VCU joined with five other two- and four-year institutions in a large-scale effort to improve the mathematics and science backgrounds of K-8 school teachers. National Science Foundation (NSF) funding of an urban collaborative grant is providing an opportunity for students, public school teachers, and college faculty to meet and discuss the development needs of the K-8 classroom teacher. As a result of this communication, college instructors can best design courses to equip future teachers in the teaching skills they need, to enhance future teachers' confidence in tackling the mathematics and science content of the K-8 curriculum, and to provide a solid foundation in their own content knowledge.

Ms. Turbeville serves as a member of the VCEPT Steering Committee and as chair of the mathematics course development team. Through this collaborative, mathematics and science
content courses and methods courses are being designed and field-tested to model best practices in teaching. The Reynolds mathematics and science faculty have been active members of many of the grant's course development teams, helping with the design of course activities. These "model" courses are showcased and taught during a Summer Institute. During 1997, three Reynolds faculty members were part of the teaching teams of the Summer Institute. It is hoped that these general education courses, which are taken by students with majors other than education, will also serve as a recruiting tool for more K-8 teachers.

During the spring semester of 1998, Reynolds initiated plans for a "teaching apprentices" program where prospective teachers are paired with a senior faculty member in a mentoring relationship. The teaching apprentice "adopts" a course, observes classes for modeling of best practices, "shadows" the instructor to learn about lesson preparation and design, and learns about one-on-one teaching by offering a weekly problem session for the class. The teaching apprentices are also invited to attend campus professional development activities, such as graphics calculator workshops.

Summer Colloquium

Reynolds assumed major planning and hosting responsibilities for the 1997 Summer Colloquium of VCEPT. As the colloquium coordinator, Ms. Turbeville lead a team of representatives from the VCEPT Collaborative, the Virginia Mathematics and Science Coalition, and the regional Mathematics and Science Center. Attended by about 125 teaching apprentices, clinical faculty, and college faculty, the three-day colloquium offered informative sessions on science, mathematics, and technology and hosted meetings of various disciplinary and interdisciplinary course development teams. The Clinical Faculty and Teaching Apprentices Standing Committees, as well as other collaborative committees, met during the Colloquium. A highlight of the colloquium was a scholarship awards ceremony held to recognize selected students, from participating VCEPT colleges, planning to enter the education profession. On a four point scale, four being the highest, the Colloquium received a mean response of 3.5 for "increased my motivation to try new teaching strategies," and a mean of 3.59 for "I will be likely to share Colloquium ideas with my colleagues during the coming year."
Experiencing Science Course

Another activity housed within the urban collaborative is the design and delivery of a three-credit interdisciplinary science course called *Experiencing Science* offered jointly by VCU and the Science Museum of Virginia to freshman liberal arts and non-science majors from both two- and four-year colleges. The course emphasizes a student-centered, investigative approach to learning science based on national science standards developed by a team of two- and four-year college professors from the disciplines of physics, chemistry, biology, mathematics, and education. Course content and assessment methodology were developed drawing upon the expertise of a team of individuals representing various disciplines and institutions including Reynolds.

This course offering is unique because it utilizes the interactive exhibit resources of the Science Museum of Virginia as its primary resource for student activities. Eight to ten primary scientific investigations carried out during class lecture time form the core of the course. Each investigation is led by a team instructor from the appropriate discipline and utilizes museum exhibits, the museum's computer facilities, and other local science resources. Student journals and research notebooks are used as an assessment tool for students and instructors. In addition to team-led investigations, the students work together to carry out an investigation of their own choosing and within the framework of the topics under study. Project results are presented in a symposium format at the end of the course.

*Experiencing Science* truly enables prospective teachers to experience the entire process of scientific investigation from the origin of the idea to the communication of the results to peers. Students enrolled in the course's first offering represented different area schools; the course was designed so that prospective teachers could replicate the methodology in their own future classrooms. A direct result of this collaboration, two new science courses are being offered at Reynolds. Human Heredity teaches the major principles of science, such as transfer of energy, transfer of information, and inter-relationship of systems, illustrated through genetics. The second course uses scientific inquiry to learn how physics, biology and chemistry are interrelated.

Team-taught Statistics Course

Another area of significant involvement of Reynolds in teacher education under the urban
collaborative umbrella is faculty collaboration on a statistical thinking course. The focus of the course is on understanding key ideas rather than mathematical formulation. Formulas are stated in words and students do very little calculation and table reading in this course.

Ms. Jovanovich was assistant chair of the VCEPT course development team for statistics and was one of the instructors in the team-taught course piloted during the summer of 1997. During the second summer colloquium this was one of the showcased courses, and visitors were able to see first-hand the learning activities of the course and ask questions of the each of the team instructors and the students. The innovative course was designed to produce "consumers of statistics" as opposed to "producers of statistics". Learning activities of the course included:

1. laboratory activities which reinforced ideas presented in lecture. Lab reflections reinforced the main concepts and encouraged specific applications.
2. focus exercises—homework problems that students attempted first and were then discussed in class. Students had an opportunity to revise their responses before submitting them to be graded.
3. class notes which were distributed to the students for reference during lectures. Students were then able to discuss and listen to the lecture and take a few notes as opposed to simply spending the class time taking notes.
4. an electronic statistical reference which was used to illustrate concepts and give students further practice in statistics.

The text used in this course featured thought questions at the start of each chapter that related to chapter topics. Through case studies and examples, it asked readers to think about statistical problems as they occur in the real world.

As a general education course, prospective teachers (non-mathematics/science majors) enroll in this course as part of their undergraduate program. It is hoped that this course will be adapted in the near future for offering at Reynolds and other two- and four-year colleges. Significant benefits were gained from the two-year college/university faculty interaction that focused on statistics.

Eisenhower-funded Geometry Project for Grades 4-8 Teachers

During the summer of 1996, a two-week summer institute entitled "Bringing Geometry
"to Life with Activities and Technology in the Mathematics Classroom" was offered by Reynolds. Ms. Jovanovich together with a Reynolds’ colleague served as proposal writers, project directors and institute co-instructors. Six teacher consultants from three local school districts assisted the project directors in planning the institute as a high-quality professional development activity on geometry and measurement for teachers from grades 4-8. Identified needs of local school divisions showed geometry as a strong area of need for teacher development. Content and pedagogy were based not only on NCTM Curriculum and Evaluation Standards [1] but also on the recently adopted Virginia Standards of Learning (SOLs) [2]. Instructional techniques in the institute modeled hands-on active participation, cooperative groups, and attention to real-world applications. Use of technology was emphasized through handheld interactive geometry on the TI-92, access to World Wide Web geometry resources, and geometry software packages. Each of the twenty-seven participants received a geometry manipulative kit and other resources. Teachers attended follow-up sessions and held in-service sessions for their peers. Many teachers commented on their frequent mentoring of colleagues, far beyond the requirements of grant participation. The geometry knowledge of more than 1200 Richmond area students was affected by teachers in this grant.

Response to the institute was overwhelmingly positive. Each participant and their respective principals and math specialists who responded would encourage other teachers from their schools to participate in similar institute at J. Sargeant Reynolds Community College. In follow-up surveys a year later, on a 6.0 scale the participants gave a mean rating of 5.1 for the extent to which the grant activities influenced their knowledge and skills. Math specialists gave an average rating of 5.5 for the same question, while principals gave a 4.4 rating. With regard to the influence of grant activities upon classroom instruction, participants gave a 5.0 average rating, math specialists gave a 6.0 rating, and then principals gave a 4.4 rating.

Regarding student learning, no exact measures were available, although one math specialist reported that the Literacy Passport Test (LPT) scores have risen. One participant reported close to 100% on the geometry section of LPT. Another participant reported that students on the fifth grade level scored above the 58 or 59 percentile in mathematics and that their class scored the highest. Alternative assessment forms yielded the greatest evidence of
improved comprehension and synthesis according to another participant. In another situation, two participants reported that more students passed the teacher-made test on geometry than usual. One person stated that although it was not measurable, it was gratifying to see "the enthusiasm the students (showed) as we did the geometry unit and the fact they kept returning to the geometry learning centers on their own and long after that unit was studied. They also came to recognize geometry concepts and use them in other subjects."

Eisenhower-funded Graphing Calculator Project for Grades 9-12 Teachers

Two two-week summer institutes on "Graphing Calculators" for secondary mathematics teachers were held at Reynolds during the summers of 1993 and 1994. With a Reynolds mathematics faculty member as proposal writer, project director, and institute co-instructor, teachers from grades 6-12 participated in courses designed to familiarize them with graphing calculator technology, technology recommendations of the NCTM Standards, and the impact of the graphing calculator on the teaching and learning of mathematics. Through intense hands-on study with follow-up sessions, participants were empowered to make a change in their instructional delivery. Thirty participants each summer from the Richmond area and from distances up to an hour away filled the courses almost immediately, with long waiting lists during both years of the project. Follow-up sessions at Reynolds and sharing sessions held by the participants for their peers served to reinforce knowledge gained and sustain the professional growth. Teachers regularly shared their resource notebook with other teachers.

Project evaluations were extremely positive. Participants were asked to evaluate the project at various times during its progress. At the end of the second two-week period, all thirty participants answered an emphatic "yes" to a question about the benefit of this course to their personal and professional growth. In follow-up sessions throughout the year, written evaluations reported that participation in this project equipped the participants very well to incorporate the graphics calculator into their teaching. To this day, school division mathematics specialists report the benefits of this Reynolds-sponsored activity.

In Summary

In addition to the above special projects, Reynolds faculty routinely participate in local, state, regional, and national conferences for teachers and prospective teachers, giving
presentations and workshops, serving as committee chairs, or holding local elected positions, such as Board member, Secretary, or President. Reynolds faculty serve on curriculum evaluation and self-study committees with area teachers and provide training of new teachers at pre-service institutes. One Reynolds mathematics faculty member, who was recently awarded the College's first faculty sabbatical leave, spent the leave period as Mathematics Educator-in-Residence at the regional Mathematics and Science Center. There she delivered mathematics through technology lessons to over 1200 students in 17 different secondary schools, thereby interacting one-on-one with more than 50 teachers. This faculty member continues to co-lead, along with Center staff, professional development activities for area teachers through daylong workshops. Informally, Reynolds faculty identifies students with an interest in teaching and encourages their participation in local conferences of teachers' professional associations. Additionally, Reynolds faculty have repeatedly served as proposal writers, project directors, and institute instructors of major grant-funded projects in teacher education.

References


INVESTING IN TOMORROW'S TEACHERS: THE INTEGRAL ROLE OF THE TWO-YEAR COLLEGE IN THE SCIENCE AND MATHEMATICS PREPARATION OF PROSPECTIVE TEACHERS

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SUMMARY

The workshop Investing in Tomorrow's Teachers: The Integral Role of the Two-Year College in the Science and Mathematics Preparation of Prospective Teachers was held in Washington, DC on March 12 – 14, 1998. Eleven exemplary two-year college programs chosen in a national competition were highlighted at the conference. Over 100 individuals participated, including faculty and administrators from two-year colleges already engaged in exemplary activities in teacher preparation; faculty and administrators from science, mathematics, and education departments in two- and four-year colleges who have
responsibility for the various components of teacher preparation; representatives from national disciplinary professional societies and organizations specifically devoted to the preparation of teachers; and current preK-12 teachers and pre-service teachers from two-year colleges. Participants considered the role of two-year colleges in the preparation of teachers and then developed a set of recommended actions.

**Current Role**

It has become increasingly apparent that the resources of the nation's community colleges must be utilized fully if the need for a teaching force well prepared in science, mathematics, engineering, and technology (SMET) is to be met. Generally, neither two-year colleges, nor the four-year institutions where teachers complete their preparation, nor the schools that hire teachers fully recognize the essential role of two-year colleges in teacher preparation. In many ways, the preparation of teachers is a hidden mission of two-year colleges. Many future elementary and middle school teachers are taking most, if not all, of their college-level science and mathematics courses at two-year colleges. Equally important is the potential for each of the nation's two-year college to provide active leadership in recruiting the next generation of elementary and secondary school teachers. Two-year colleges, with their orientation towards teaching and their strategic locations, are in a pivotal position to recruit and help prepare the next generation of science and mathematics teachers as well as give students preparing to teach in the elementary grades a strong grounding in science, mathematics, and technology.

**Recommended Actions**

Recommendations for action were developed in the following areas:

- recruitment of prospective teachers;
- strengthening undergraduate science, mathematics, engineering, and technology courses;
- pre-teaching experiences;
- in-service activities;
- liaisons between two-year colleges and four-year institutions; and
- connections with business and industry, professional societies, and other organizations.

The recommendations, detailed in this report and summarized below, address actions two-year
colleges can undertake by themselves and in partnership with four-year colleges or professional societies.

Two-year colleges should:

- Recruit and attract the best students to the teaching of science, mathematics, engineering, and technology.
- Actively involve SMET faculty and administrators in institution-wide recruitment of prospective teachers through such activities as visiting area high schools in coordination with guidance counselors or participating in on-campus visitation days for prospective students.
- Include teacher preparation efforts into the colleges' mission and strategic plans.
- Provide meaningful and frequent professional development in SMET both within and across disciplines for full-time and adjunct faculty.
- Offer continuing education programs for teachers as a regular component of workforce training initiatives to meet the needs of regional employers.

Two-year colleges should collaborate with four-year colleges and universities and school systems to:

- Coordinate student advising for prospective teachers between two-year and four-year institutions concerning the transfer of courses, financial support, and program requirements.
- Eliminate the barriers of course transferability by articulating transfer agreements between two-year colleges and four-year institutions that are mutually established through open communication concerning specific course content and expectations.
- Design and implement high-quality science, mathematics, and technology curricula.
- Engage potential teachers in preK-12 tutoring, mentoring, and enrichment programs in SMET fields.
- Cooperate with local school districts and institutions such as science museums and mathematics and science centers to provide SMET pre-teaching experiences for two-year college students.
- Engage potential teachers as teaching assistants in inquiry-based SMET classroom and laboratory settings and in testing and evaluation.
- Engage professionals in the community from business and industry to provide students and
faculty in two-year colleges with information and perspective about how science, mathematics, and technology are applicable to teaching and other career tracks.

- Promote joint professional education activities involving student groups between two-year colleges and four-year institutions.
- Work with local school systems and state policy officials to establish stronger teacher certification standards.

Professional societies should work with two-year colleges to:

- Highlight the roles of two-year colleges in the science and mathematics preparation of future teachers.
- Seek students from two-year colleges for membership and welcome as members two-year college students who wish to pursue careers as teachers.

Implementation of the recommendations of this report requires all groups involved in the preparation of teachers to take a more proactive role than in the past. Two-year colleges must plan and work cooperatively with four-year colleges and universities, school systems, professional societies, business and industry, state, local, and national government agencies, and with each other. No one group can do it alone. All must cooperate. With support from the National Science Foundation and others who share this vision, two-year colleges can help our nation produce a teaching workforce highly qualified in science, mathematics, and technology.

INTRODUCTION

In order to better understand and increase the awareness of the role of two-year colleges, a major resource in teacher preparation, the Division of Undergraduate Education of the National Science Foundation (NSF) convened a national conference The Integral Role of the Two-Year College in the Science and Mathematics Preparation of Prospective Teachers in Washington, DC on March 12 – 14, 1998. Eleven exemplary two-year college programs chosen in a national competition were highlighted at the conference. In introducing them, the NSF’s director, Dr. Neal Lane, remarked:

*The exemplary activities being showcased here accomplish the best of all possible*
educational objectives. They equip students with skills that enable them to step directly into today's technological workforce. They also provide the broader opportunities to learn mathematics and science and to practice habits of mind and problem solving techniques that will serve students well if they are called to teaching or other careers.

At the conference, science and mathematics faculty, presidents, and other administrators from these eleven colleges joined other national leaders to assess successful two-year college teacher preparation approaches underway and to develop specific recommendations concerning how two-year colleges can better help to meet the national need for well-prepared teachers of science, mathematics, and technology. This role of helping to prepare future teachers was recognized as consistent with the community based and student centered missions articulated by two-year colleges. Yet, the role of two-year colleges in teacher preparation has often gone unrecognized. In many ways, the preparation of teachers is a hidden mission of two-year colleges.

Over 100 individuals participated, including:

- faculty and administrators from eleven two-year colleges who are among those already engaged in exemplary activities in teacher preparation;
- faculty and administrators from science, mathematics, and education departments in two- and four-year colleges who have responsibility for various components of teacher preparation;
- representatives from national disciplinary professional societies and from organizations specifically devoted to the preparation of teachers; and
- current preK-12 teachers and pre-service teachers from two-year colleges.

Participants developed detailed recommendations concerning the role of two-year colleges in the following areas:

- recruitment of prospective teachers;
- strengthening undergraduate science, mathematics, engineering, and technology courses;
- pre-teaching experiences;
- in-service activities;
liaisons between two-year colleges and four-year institutions; and
connections with business and industry, professional societies, and other organizations.

Subsequent sections of this report lay out the conference’s specific recommendations articulating how two-year colleges can move individually and collectively to ensure that all involved in the science, mathematics, and technology preparation of prospective teachers recognize the crucial role of two-year colleges and that two-year colleges with their partners develop programs that meet the national need for well-qualified teachers.

**BACKGROUND**

The science, mathematics, and technology preparation of the next generation of teachers is critical to the social and economic future of the nation. Demographics indicate that the nation’s colleges and universities must begin to produce many more teachers than they are currently producing. There is an even greater need for teachers willing and prepared to teach in the inner cities, in remote rural areas, and in schools with large minority populations and for mathematics and science teachers in all regions. The performance of United States students on international tests suggests that it is no longer acceptable to put into classrooms large numbers of middle and high school science and mathematics teachers who have neither majored nor minored in mathematical or scientific disciplines. Nor is it acceptable to hire elementary school teachers with inadequate preparation in science and mathematics.

Historically, teacher preparation has been considered the province of a small number of four-year colleges and universities. While two-year colleges have always played an unrecognized role in teacher preparation, with support from NSF and their communities, two-year colleges are beginning to take more active leadership roles in undergraduate science, mathematics, engineering, and technology (SMET) instruction, and in particular in the science and mathematics courses taken by future teachers. Currently, two-year colleges enroll nearly half of all United States undergraduates and over one-third of all students taking science, mathematics, and engineering and technology (SMET) courses. In increasing numbers, two-year colleges are recruiting more future teachers, providing them with stronger mathematical and scientific preparation, and utilizing their college resources to meet the challenges facing
elementary and secondary education. According to Luther Williams, NSF's Assistant Director for Education and Human Resources,

"The resources of the nation's community colleges must be utilized fully if the need for a teaching force well prepared in science, mathematics, engineering, and technology is to be met."

**THE NEED**

The number of new teachers that will be needed within the next decade is daunting. The U.S. Department of Education predicts that 40% of current public school teachers will retire or leave the profession by the 2003-4 school year. At the same time, school enrollments are rising dramatically. In the next ten years, America will need to hire two million new teachers to replace the generation of teachers about to retire and to keep up with rising enrollments. The NSF report *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology* (NSF 96-139), as well as many other studies, have made a persuasive case that America's future teachers require stronger backgrounds in science, mathematics, and technology. The number of teachers essential for a strong school system becomes even greater as additional states legislate limits on class sizes.

In many parts of the country, a large percentage of elementary and middle school science and mathematics classrooms are currently being staffed by teachers with little or no college-level training in science or mathematics. In his address *The State of Mathematics Education: Building a Strong Foundation for the 21st Century* on January 9, 1998 at the annual joint meeting of the American Mathematical Society and the Mathematical Association of America, U.S. Secretary of Education Richard Riley lamented:

*Presently, 28 percent of high school math teachers do not have a major or minor in mathematics. The average K-8 teacher takes three or fewer mathematics or mathematics education courses in college. Furthermore, fewer than one-half of 8th grade mathematics teachers have ever taken a course in the teaching of mathematics at this level. Equally distressing, the teacher qualifications are even lower in low income and minority schools. We must do better.*
Secretary Riley also noted that 18 percent of high school science teachers neither majored nor
minored in science. In the physical sciences, where 12th grade student performance lags the
most in international assessments, almost half of American students are taught by teachers
without a major or minor in that field.

The recently released reports of the Third International Mathematics and Science Study
(TIMSS) reveal that U.S. students are less successful than their counterparts in other nations
as they progress through the various grade levels. Although students in elementary grades at
least match international averages in the TIMSS, the performance of high school seniors is
almost last in both mathematics and science. The reasons for this poor level of performance
are complicated, but significant improvement would be encouraged by a teaching corps that
is well prepared in both content and pedagogy of science, mathematics and technology.

Many new teachers must be encouraged, willing, and prepared to teach in the inner cities, in
remote rural areas, and in schools with large minority populations. In July of 1997, President
Clinton also called attention to the need for well-trained college graduates to enter the teaching
profession and, in particular, to the critical need for teachers who can serve as role models for
inner-city students.

ROLE OF TWO-YEAR COLLEGES

According to data gathered by the American Association of Community Colleges (AACC),
the more than 1,100 two-year colleges across the country currently enroll about 45% of all
U.S. undergraduates, with more than 5 million students in credit classes (1997 AACC Facts,
1997). In the fall of 1992, two-year institutions accounted for over 40% of all undergraduate
science, mathematics, engineering, and technology courses and 34% of all undergraduate
SMET course enrollments (Shaping the Future). While precise data do not exist, it is
estimated that more than 40% of teachers completed some of their science and mathematics
course work at two-year colleges. Indeed, many future elementary and middle school teachers
are taking most, if not all, of their college-level science and mathematics courses at two-year
colleges.
Generally, neither two-year colleges, nor the four-year institutions where teachers complete their preparation, nor the schools that hire them fully recognize the essential role of two-year colleges in teacher preparation. The fact that two-year colleges are already heavily engaged in the mathematical and scientific preparation of teachers is one reason to recognize more prominently this priority of two-year schools. However, an equally important reason is the opportunity of each two-year college in the nation to make important contributions to recruiting and training the next generation of elementary and secondary school teachers. Because excellent instruction is the primary focus at two-year colleges, their faculty members are well positioned to provide leadership in the quality of instruction in mathematics and science. Furthermore, two-year colleges are often located in regions directly serving rural and urban communities where new teachers will be needed most. Thus, two-year colleges, with their orientation towards teaching and their strategic locations, are in a pivotal position to recruit and help prepare the next generation of science and mathematics teachers as well as give students preparing to teach in the elementary grades a strong grounding in science, mathematics, and technology.

RECRUITMENT OF PROSPECTIVE TEACHERS

Two-year colleges play a critical role in attracting people with a high potential for becoming excellent teachers. These institutions are strategically positioned in urban and rural regions, enroll a large proportion of the nation’s minority college students, and welcome returning adults. Given this large and diverse student body, the nation benefits to the extent that the most talented in this large student population consider teaching as a career option.

In an effort to expand the pool of prospective teachers and to improve the academic preparation of teachers in SMET, two-year colleges must identify, attract, nurture, and guide individuals from within their student population who have the potential to become excellent teachers. Recruitment and encouragement of prospective future teachers at two-year colleges should be undertaken as a comprehensive, coordinated effort, tied directly to the institution’s long-term strategic plan. State policies and structures should be reevaluated to ensure that they do not hinder efforts to recruit new teachers. Most importantly, SMET college faculty and advisors must heighten respect for the teaching profession as a worthy career for outstanding students.
Recognizing that they have a major role to play in the recruitment of students into careers in teaching, two-year colleges should:

- Recruit and attract the best students to the teaching of science, mathematics, engineering, and technology.
- Actively involve SMET faculty and administrators in institution-wide recruitment of prospective teachers through such activities as visiting area high schools in coordination with guidance counselors or participating in on-campus visitation days for prospective students.
- Work collaboratively with school systems and four-year institutions to develop recruitment and retention programs.
- Create networks among business and industry and community-based and religious organizations for effective recruitment into teaching.
- Join with professional associations to initiate public campaigns on community, state, and national levels to emphasize the need, importance, and rewards of teaching as a profession.
- Recruit potential teachers from various segments of the population, including minorities and underrepresented groups, mid-career changers, paraprofessionals, and other nontraditional students.
- Provide prospective students with complete information regarding pathways to SMET teacher certification.
- Provide students with research-oriented science experiences that encourage them to consider science or mathematics as an academic major and teaching as a profession.
- Advocate for financial incentives such as scholarships, loans, or loan forgiveness on the federal and state levels for students who plan to teach.
- Encourage businesses and foundations to develop and/or expand financial incentives for students who plan to teach.
- Offer programs with strong SMET components to prepare paraprofessionals for full certification.
- Include teacher recruitment efforts in the colleges’ mission and strategic plans.
INVESTING IN TOMORROW’S TEACHERS: THE INTEGRAL ROLE...

STRENGTHENING UNDERGRADUATE SCIENCE, MATHEMATICS, ENGINEERING, AND TECHNOLOGY COURSES

Two-year colleges have a responsibility to ensure that prospective teachers complete science, mathematics, and technology courses of the highest quality. Programs of study for future teachers should include multidisciplinary approaches and be informed by discipline based research in teaching and learning as well as research in education and cognitive science. Because teachers usually base their own teaching approaches on the way that they have been taught, it is vital that college courses emphasize inquiry activities and experiential discovery.

Excellence in instruction is the primary focus at two-year colleges. Thus two-year college science, mathematics, engineering, and technology faculty are positioned to provide national leadership in the quality and nature of instruction. Many future preK-12 teachers choose teaching as a career after completing the first two years of college. Structuring all two-year college mathematics and science instruction to reflect active, participatory, discovery-oriented approaches provides those students who become teachers a sound foundation in both the content and methods of science and mathematics and enhances the entry-level mathematics, science, and technology experiences for all students.

Two-year college SMET faculty should:

- Ensure that SMET courses and experiences become more centered in the student and the processes of the SMET disciplines.
- Ensure that all students have frequent access to inquiry-based experiences in and outside of class.
- Collaborate with preK-12 teachers and four-year faculty to design and implement high-quality science, mathematics, and technology curricula.
- Integrate results of cognitive research and standards-based curriculum development into SMET instruction.

Two-year colleges SMET departments should:

- Hire and support full-time and adjunct faculties who incorporate standards-based instruction.
• Provide meaningful and frequent professional development in science, mathematics, engineering, and technology both within and across disciplines for full-time and adjunct faculty.

• Encourage and support full-time and adjunct faculty's participation in professional organizations and development activities.

• Provide reassigned time for faculty to engage in classroom research, curriculum development, and dissemination.

Federal, state, and private funding agencies should support:

• Development of standards-based SMET curricula at the introductory college level.

• Collaboration among preK-12 teachers, two-year college faculty, and four-year college and university faculty to implement curricula.

• Local and regional initiatives that enhance communication and collaboration among SMET and other disciplines.

• Professional development activities for faculty who teach in SMET fields.

**PRE-TEACHING EXPERIENCES**

Experiences that introduce students to the excitement of helping others to learn and acquaint them with the rewards of teaching are critical to the recruitment and development of the workforce of future teachers. Two-year colleges, in collaboration with others, should actively seek to engage students and faculty in authentic pre-teaching experiences that encourage and support prospective teachers. In order to provide this engagement, each college must assess its current policies and practices, and a full commitment must be made through initiatives at local, state, and national levels.

Two-year colleges should:

• Engage potential teachers in preK-12 tutoring, mentoring, and enrichment programs in SMET fields.

• Cooperate with local school districts and institutions such as science museums and mathematics and science centers to provide pre-teaching experiences.

• Engage potential teachers as teaching assistants in inquiry-based SMET classroom and laboratory settings and in testing and evaluation.
INVESTING IN TOMORROW'S TEACHERS: THE INTEGRAL ROLE...

- Support faculty efforts to initiate programs of SMET pre-teaching experiences for prospective teachers.
- Work with four-year colleges and universities to provide structured opportunities for prospective teachers to visit preK-12 classrooms and to observe a variety of science and mathematics teaching strategies, use of technology, assessment, and individual work with students.
- Provide prospective teachers with support structures (future teacher associations, faculty mentoring, and advising programs) that provide career exploration and articulate transfer paths to professional certification.
- Acknowledge pre-teaching activities through formal recognition, student record annotation, and other incentives.
- Provide financial support and incentives such as internships to encourage students to engage in pre-teaching experiences.
- Work with industry and business to enable future teachers to learn about the role of science, mathematics, and technology in the workplace.
- Work with four-year colleges and universities and the schools to provide early field experiences for students.

IN-SERVICE ACTIVITIES

From the college faculty point of view, in-service and pre-service activities are closely linked. Two-year colleges, with their presence in many communities, are a natural resource for delivering professional development for preK-12 teachers. Two-year college faculty are well versed in working with adult learners and are well positioned to take leadership roles in providing and supporting these in-service activities. A by-product of participation by two-year college faculty in in-service activities is an increased appreciation of the value of standards-based instruction that may be reflected in improvements to their own college courses. In particular, participation in in-service teacher training may generate faculty involvement and interest in the recruitment and preparation of prospective teachers at two-year colleges.
Two-year colleges should:

- View the provision and support of strong SMET in-service programs for current preK-12 teachers as an area of high priority.
- Offer continuing education programs for teachers as a regular component of workforce training initiatives to meet the needs of regional employers.
- Work collaboratively with other providers of professional development opportunities to offer a rich overall continuing education program in all SMET areas.
- Recognize that, in many rural areas, the two-year college must serve as the primary provider of continuing education opportunities and, in conjunction with area school systems and four-year institutions, develop a comprehensive in-service SMET program.
- Design SMET professional development activities that foster utilization of research-based and standards-based pedagogy.

Professional associations should:

- Seek adequate funding for mutually beneficial partnerships among two-year colleges, preK-12 schools and other contributors to SMET teacher professional development.
- Create SMET programs that simultaneously address the continuing professional development needs of faculty from preK-12 schools, two-year colleges, and four-year institutions.

Two-year college administrators should:

- Support professional development opportunities in SMET such as team teaching, teacher exchanges, sabbatical assignments, and peer observation among faculty from preK-12 schools, two-year colleges, and four-year institutions.
- Provide incentives for the professional growth and development of all faculty who participate in the science, mathematics, and technology preparation of prospective preK-12 teachers.
- Establish expectations that all faculty who participate in the science, mathematics, and technology preparation of prospective preK-12 teachers be involved in ongoing professional growth and development activities.
Traditionally the preparation of teachers of science and mathematics has been viewed as the exclusive purview of four-year institutions. Because a large percentage of prospective preK-12 teachers begin their education in two-year colleges, two- and four-year colleges must work collaboratively in the science, mathematics, and technology preparation of future teachers. Not only do students at two-year colleges transfer to four-year institutions to complete their education training and certification, but faculty at two-year colleges are themselves the product of the four-year institutions. Although two- and four-year colleges have different overall missions, in the area of science and mathematics teacher preparation, they must share a common goal to prepare preK-12 teachers who are well trained, qualified, and motivated.

To reduce barriers that hinder smooth transition of prospective teachers, colleges and universities need to improve transfer programs, partnerships, and professional development opportunities.

Two- and four-year colleges and universities should:

- Work together to develop two-year college SMET programs that provide seamless transition to teacher preparation programs at four-year institutions.
- Coordinate student advising for prospective teachers between two-year and four-year institutions concerning the transfer of courses, financial support, and program requirements.
- Eliminate the barriers of course transferability by articulating transfer agreements between two-year colleges and four-year institutions that are mutually established through open communication concerning specific course content and expectations.
- Reduce the cultural barriers and misconceptions between two-year colleges and four-year institutions by encouraging the exchange of faculty and facilitating SMET topical workshops.
- Support transition of students through the personal involvement of SMET faculty at two-year and four-year institutions.
- Work collaboratively to ensure that two-year colleges and four-year institutions are both represented as preK-16 SMET educational policy is formulated.
• Increase the number of partnerships between two-year colleges and four-year institutions focusing on joint SMET program development and dissemination.
• Promote joint professional education activities involving student groups between two-year colleges and four-year institutions.
• Work with local school systems and state policy officials to establish stronger teacher certification standards.
• Develop collaboratively a teaching track for M.S. and Ph.D. SMET students whose career goal is to teach at two-year colleges.
• Increase sustainable joint SMET professional development opportunities (co-teaching, teacher exchange, and others) by preK-12 institutions and two- and four-year colleges for full-time and adjunct faculty.
• Encourage partnerships that jointly address major public issues facing SMET educational policy and practice (e.g., adoption of standards, approaches to teaching practices and content, mandatory program requirements, expectations of students’ skills and knowledge, appropriate role of technology in SMET teacher preparation, and roles of teaching assistants and adjunct faculty in preK-12 SMET teacher preparation.)

CONNECTIONS WITH BUSINESS, INDUSTRY, AND PROFESSIONAL SOCIETIES

Two-year colleges contribute significantly to the economic health and vitality of the cities or regions in which they are located. As a result, groups or organizations that have a stake in the success of students at two-year colleges can have great influence on two-year college programs. These include SMET professional societies at local, regional, state, and national levels as well as business and industry, other professional societies, parents, informal education agencies, museums, legislative bodies, and accrediting agencies. Awareness by these communities of the contributions of two-year colleges in the science, mathematics, and technology preparation of prospective teachers is vital. Two-year colleges should convene forums on their campuses with representatives from state legislatures, members of the preK-12 and higher education communities, and business and industry to discuss issues of SMET teacher preparation.
Business and industry should:

- Provide internships and other opportunities to enable future teachers and teacher educators to learn about the role of science, mathematics, and technology in the workplace.
- Communicate clearly to future teachers expectations about the desired characteristics of potential employees.
- Provide scholarships for students and support for equipping laboratories and enhancing technology.
- Engage professionals in the community to provide students and faculty in two-year colleges with information and perspective about how science, mathematics, and technology are applicable to teaching and other career tracks.

SMET Professional Societies should:

- Highlight the roles of two-year colleges in the science and mathematics preparation of future teachers.
- Seek students from two-year colleges for membership and welcome as members students who wish to pursue careers as teachers.
- Promote opportunities for full participation of prospective SMET teachers at professional meetings.
- Establish student chapters on two-year college campuses.
- Recruit faculty from two-year colleges to join and assume leadership roles.
- Publicize efforts by two-year colleges in teacher preparation through various media and to a variety of targeted audiences.

A CALL FOR ACTION

The science, mathematics, and technology preparation of the next generation of elementary and secondary school teachers is a critical national concern. Every two-year college in the country has the opportunity and responsibility to address this challenge. This leadership conference calls upon the nation’s two-year colleges to make teacher preparation in SMET a major priority. This requires assessment by each college of its priority and current practices and full commitment on the part of all sectors of the two-year college community—presidents,
trustees, faculty, and students—and collaborations with all pertinent education and community sectors.

Participants in this workshop developed a comprehensive set of detailed recommendations concerning the role of two-year colleges:

- **Two-year colleges should actively recruit prospective teachers from the areas that the two-year colleges serve.** Two-year colleges are uniquely placed to participate in recruiting the numbers of teachers that are needed nationally and, in particular, to recruit future teachers who can best understand the needs of the communities that the colleges serve.

- **Two-year colleges should demonstrate leadership in strengthening the undergraduate mathematics, science, and technology courses taken by prospective teachers at both two- and four-year colleges.** Two-year college faculty specialize in the development and teaching of freshman and sophomore courses and are therefore in a pivotal position to provide national leadership in this area.

- **Two-year colleges should provide rich and varied pre-teaching experiences in SMET for their students.** Students beginning their undergraduate work need pre-teaching opportunities including mentoring and tutoring preK-12 students and serving as instructor aides in a variety of elementary, secondary and college settings. The activities can help students confirm their interest in teaching mathematics and science by involvement in pre-teaching experiences that foster creativity, curiosity, and inquiry.

- **Two-year colleges should provide in-service SMET courses and experiences for current teachers.** Providing continuing education in science, mathematics, and technology is particularly important for two-year colleges located in large urban areas with specific needs. In many rural areas, the two-year college must serve as the primary provider of comprehensive in-service programs, developed in conjunction with local school systems.
Conference participants also recognized that activities by two-year colleges related to teacher preparation must be undertaken in conjunction with four-year institutions and others involved in the science, mathematics, and technology preparation of prospective teachers.

- **Two-year college efforts in the preparation of teachers must take place in close coordination with four-year institutions.** Careful attention must be paid to articulation agreements and clear policies must be developed concerning transfer, joint advising, and joint-registration.

- **Two-year colleges and four-year institutions must collaborate to strengthen and align science, mathematics, and technology courses for prospective teachers, to establish student transfer agreements, and to provide mutual support for one another’s role in teacher education.**

- **Two-year colleges must become full partners in all discussions about the SMET preparation of future teachers.** Fully engaging two-year colleges in the preparation of teachers will require liaisons with business and industry, professional societies, state legislatures, and statewide and national policy boards.

- **Faculty in two- and four-year colleges and universities should establish cooperative ventures affecting teacher preparation activities.** A dialogue between faculty should be established among two-year colleges, four-year college and university science and mathematics departments, and colleges of education.

It is the expectation of conference participants that the above recommendations will lead to action. Conference participants, professional societies, and other national leaders designed to highlight the role of the two-year college in teacher preparation are already accomplishing much; however, further efforts must also take place nationally.

- **The need for more information was highlighted.** Conference participants recognized as a high priority the need for more detailed information concerning the role of two-year colleges in the SMET preparation of teachers. In particular, data should be collected on
a national level to determine what percentage of new teachers studied mathematics and science education at two-year colleges and the extent of the studies.

- **Effective partnerships are needed involving many groups.** Two-year colleges should work with the American Association of Colleges for Teacher Education (AACTE), the Holmes Partnership, and others, to facilitate understanding and recognition of the role of two-year colleges in teacher preparation.

- **External support is needed to initiate change.** Financial support from federal, state, corporate, and foundation sources is necessary for full implementation of these recommendations.

**ACTIONS TAKEN AS A RESULT OF WORKSHOP**

- Two-year college presidents, deans, and other administrators returned from the conference and committed their institutions and systems to an increased focus on the preparation of SMET teachers.

- The American Association of Community Colleges (AACC) is sending letters to all two-year colleges announcing the recommendations of this conference. The communication includes testimonials from presidents at the colleges recognized at this conference, indicating the impact that teacher preparation initiatives have had on their institutions.

- The American Mathematical Association of Two-Year Colleges (AMATYC), through the Teacher Preparation Subcommittee of its Program/Curriculum Issues Committee, is referring the recommendations to the AMATYC membership for action. AMATYC has included in its next conference program sessions featuring the teacher preparation activities of the colleges recognized at this conference. Recent AMATYC newsletter articles have addressed the conference activities.

- The American Association of Physics Teachers, through its Two-Year College in the Twenty-First Century (TYC21) program, has formed a national alliance of fifteen regional networks. A special "Bridges" session at the 1998 summer TYC21 conference
addressed bridging activities concerning the training of prospective precollege teachers and showcased many of the exemplary activities.

- The Virginia Mathematics and Science Coalition in conjunction with the National Association of Statewide Science and Mathematics Coalitions (NASSMC) has agreed to devote a special issue of *The Journal of Mathematics and Science: Collaborative Explorations*, to the conference and reports of the work of the eleven exemplary activities.

- The League for Innovation in the Community College has invited members of the Conference Steering Committee to submit a Leadership Abstract on the role of two-year colleges in preK-12 teacher preparation.

- The Mathematical Association of America (MAA) has highlighted the work of the conference and the role of two-year colleges through a feature article in FOCUS: “Enlisting Two-Year Colleges in Educating Mathematics Educators.”

- Recruiting New Teachers, Inc. is conducting a study of community college programs that both encourage and enable prospective teachers to complete the baccalaureate degree and link to teacher preparation.
AIMS & SCOPE

Articles are solicited that address aspects of the preparation of prospective teachers of mathematics and science in grades K-8. The Journal is a forum which focuses on the exchange of ideas, primarily among college and university faculty from mathematics, science, and education, while incorporating perspectives of elementary and secondary school teachers. The Journal is anonymously refereed, and appears twice a year.

The Journal is jointly published by the Virginia Mathematics and Science Coalition and the National Alliance of State Science & Mathematics Coalitions.

Articles are solicited in the following areas:

- all aspects of undergraduate material development and approaches that will provide new insights in mathematics and science education
- reports on new curricular development and adaptations of ‘best practices’ in new situations; of particular interest are those with interdisciplinary approaches
- explorations of innovative and effective student teaching/practicum approaches
- reviews of newly developed curricular material
- research on student learning
- reports on projects that include evaluation
- reports on systemic curricular development activities
The Journal of Mathematics and Science: Collaborative Explorations is published in Spring and Fall of each year. Annual subscription rates are $20.00 US per year for US subscribers and $22.00 US per year for non-US subscribers.

All correspondence, including article submission, should be sent to:

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- For article submission, send three copies of the manuscript.
- The body of the paper should be preceded by an abstract, maximum 200 words.
- References to published literature should be quoted in the text in the following manner: [1], and grouped together at the end of the paper in numerical order.
- Submission of a manuscript implies that the paper has not been published and is not being considered for publication elsewhere.
- Once a paper has been accepted for publication in this journal, the author is assumed to have transferred the copyright to the Virginia Mathematics and Science Coalition.
- There are no page charges for the journal.
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