

## The North Carolina Middle Math Project: A Professional Development Project to Improve Grade 6–8 Mathematics Education

*Improving teacher quality is at the heart of our national effort to achieve excellence in the classroom. We need a dramatic overhaul of how we recruit, prepare, induct and retain good teachers. The status quo is not good enough. And we must revamp professional development, as we know it. (Secretary Riley's State of Education Address, Durham, North Carolina, February 22, 2000).*

The North Carolina Middle Math Project (NCM<sup>2</sup>) is a four-year collaboration between the Mathematics and Science Education Network (MSEN) of the University of North Carolina and the North Carolina Department of Public Instruction (NCDPI). The goal is to improve mathematics education in grades 6–8 across the state of North Carolina, supporting teachers in their professional development and providing academic renewal and financial recognition to support their retention. Nine MSEN mathematics and science education centers, located throughout the UNC system, will combine their efforts and the talents of faculty, school system administrators, and middle school mathematics teachers. Collaboration between the discipline-based faculty, the education faculty, and the middle grades teachers will ensure that the courses being developed include a multi-dimensional approach to meet the continued learning needs of middle grades teachers.

The NCM<sup>2</sup> Project is divided into four phases. In the first phase, which began preliminary to the submission of this proposal, the North Carolina Mathematics and Science Education Network (MSEN) and the North Carolina Department of Public Instruction sponsored a series of cross-disciplinary meetings to conceptualize a program that would meet three goals: develop a state-wide leadership network of middle grades mathematics teachers; address the serious issue of teacher renewal, recognition and retention; and improve the mathematics achievement for *all* middle grades students. Each university-based center in the MSEN was invited to bring a mathematician, a mathematics educator, a school system administrator, and two teachers to participate in these discussions.

Together we learned about new NSF-funded middle grades mathematics curricula; reviewed and evaluated data from international, national and state level testing; reflected on the strengths and weaknesses in other professional development opportunities; and examined national and state level efforts to recognize and reward the professional development of teachers. The NCM<sup>2</sup> co-PI's were charged with creating a model for achieving the project's goals. The following is a result of the collective efforts of those who participated in the development of the project.

In the second phase, a statewide leadership network will be created to support the development of a model for the professional renewal, recognition and retention of middle grades mathematics teachers. This effort will include the creation of three graduate courses, providing a system for supporting middle school mathematics teachers in achieving National Board Certification, providing support to encourage and help teachers to pursue graduate studies, and providing leadership at the school and district level to support improving middle school mathematics education through modeling standards-based teaching, serving as mentors for other novice teachers, and providing professional development opportunities for their peers.

In the third phase, the retention, recognition, and renewal (3-R's) model created by the NCM<sup>2</sup> Leadership Network will be offered statewide through nine institutions to 135 teachers over a period of two-years.

Finally, in the fourth phase, the NCM<sup>2</sup> Leadership Network will review and refine the model for dissemination and replication. The NCM<sup>2</sup> Leadership Network will serve as a leadership pool to assist the NC Department of Public Instruction and the MSEN in sustaining and spreading the effort to improve grade 6–8 mathematics education in North Carolina.

## ***Results from Prior NSF Support***

The proposed teacher retention, recognition, and renewal project is a natural outcome of the MIDDLE MATH Undergraduate Faculty Enhancement (UFE) Project funded by the NSF's Division of Undergraduate Education (DUE-9455152), the North Carolina Statewide Systemic Initiative; and East Carolina University. The MIDDLE MATH UFE Project involved 59 mathematicians and mathematics educators from over twenty institutions of higher education. The participants represented a cross-section of mathematicians and mathematics educators from community colleges, four-year colleges, and universities. They were from mathematics departments and education departments and included 22 faculty from across North Carolina.

The evaluation component of the project was designed around the first summer conference (August 1995), the 1995-96 academic year curriculum development, and the second summer conference (June 1996). The first summer conference provided opportunities for participants to look back and look ahead. Three NSF-funded Middle School Mathematics Teacher Preparation Projects (1986-1991) were reviewed and discussed. Participants were introduced to five NSF-funded standards-based curriculum projects for middle school mathematics. The developers of these curricula presented introductory workshops for the faculty and prescribed changes in undergraduate teacher preparation necessary to prepare teachers ready to implement the new curricula.

In the project evaluation, participants proposed a model program that they would design for middle grades mathematics teachers. Responses concerning model teacher preparation programs primarily fell into two categories: mathematical content knowledge and pedagogical content knowledge (Shulman, 1986). Knowledge of mathematical content included both knowledge of school mathematics and knowledge of more advanced mathematics. Many participants also described ways to improve the teaching of mathematics.

*I believe that the teacher's understanding of mathematics and its relationship to the middle grades curriculum provide a necessary, but not sufficient, foundation for that teacher creating a supportive learning environment for students.*

Pedagogical content knowledge includes knowledge of teaching mathematics, knowledge of the learning of mathematics, and knowledge of the mathematics learner. Many participants recognized that development of pedagogical content knowledge involves more than just a methods course. Several participants commented that content courses could also contribute to preservice teachers' knowledge by modeling appropriate and effective teaching techniques. Many participants commented that we should teach teachers in the manner that we want them to teach.

*My model program would blend (or attempt to balance) key research issues with practical "hands-on" types of assessments (e.g., clinical interview studies, classroom action research) which get teachers themselves generating case studies and teaching experiments and thinking critically about how students learn mathematics.*

*If teachers reflect on their own learning process, they will come to realize that teaching is not only telling, and learning is not only repeating. They will become aware that teaching and learning are dynamic and interrelated activities in which the teachers and the students should be actively engaged.*

The curriculum projects provided a catalyst or motivation for thinking about features of their entire programs. Almost all participants recognized that their programs were not preparing teachers to teach with the new curricula that were presented.

*It appears to me that our middle grades education majors learn too little about "school" mathematics and entirely too little about the teaching of mathematics. Our mathematics content courses are high level courses, presented in predominately lecture format with emphasis on the theoretical development of mathematics. Our preservice teachers are not experiencing mathematics learning in these classes as described in NCTM's Professional Standards for Teaching Mathematics, and, as such, are not experiencing the curriculum described in NCTM's Curriculum and Evaluation Standards (the basis of the three middle*

*grades curriculum projects [seen today]). Therefore, it is highly unlikely that the methods course could begin to convert preservice teachers to NCTM's model of good mathematics teaching and learning. This problem is further compounded by the scarcity of good field experience placements -- placements in which inservice teachers are modeling NCTM's model of good mathematics teaching and learning.*

*The new curriculums are very different from the middle school curriculum I remember when I was in middle school. If these new curricula are indications of the type of curriculum that is to be taught in public and private middle schools then the way teachers are trained must be drastically changed. Since teachers teach the way in which they are taught that means that I must change the way I teach my college classes. I need to incorporate the problem solving, collaborative learning, and critical thinking these prospective teachers will be using in their classrooms into my classroom. I also need to learn alternative forms of assessment and how to use them to evaluate my students.*

During the 1995-96 academic year, participants were asked to modify or develop at least one course for their middle grades teacher preparation program. The purpose of the second summer conference was to provide opportunities for participants to present their results and to learn from each other. They discussed their course, programs, and other issues in poster sessions, formal presentations, and working groups, called "talk about" sessions.

Participants' comments from the second summer conference indicated that significant thought and work had gone into their teacher preparation programs during the previous year. Participants had returned to their institutions after the first summer conference and had modified their programs and proposed new courses. During the second summer conference, participants were looking for activities, resources, and ideas for their classes. Some of the specific ideas cited included—

- Lab activities for courses using the CBL.
- Algebra Lab Gear for modeling operations with polynomials.
- Using pattern blocks for teaching fractions and geometric concepts.
- Having students write a letter to a parent about a hypothetical student.
- Using the World Wide Web to search information and collect data.

During the second summer conference, East Carolina University presented its curriculum research and development model. At least six of the participants wrote about this in their journal reflections.

*Research and knowledge base needs to be more of a factor in deciding program and course content. . . . These [ideas] all seem to say to me that there may profitably be a greater need to examine the knowledge base, belief systems and the like, and to build variation and experimentation, and particularly research, into programs.*

*I am impressed with the use of a one-on-one interview to assess student progress. The use of a variety of tasks in this setting could aid in triangulation toward where the students are.*

More participants at the second conference than at the first conference discussed issues related to assessment. Over two-thirds of the participants wrote about assessment in their journal reflections. They wrote about incorporating a variety of assessment techniques into their courses and throughout their program — techniques such as performance assessment (in particular with the use of manipulatives), interviews, portfolios, and gateway tests for "basic" mathematical skills.

Mathematical modeling was mentioned more frequently at the second conference than any other curriculum topic. Participants were struggling with the questions "What is mathematical modeling?" and "What is its place in the teacher preparation program?"

The MIDDLE MATH UFE Project has not produced a template or checklist for designing a teacher preparation program for middle grades mathematics teachers. Instead a more important accomplishment of this project is the information and direction that it offers to all who are interested in developing or revising effective mathematics teacher preparation programs. In its

dissemination phase, the MIDDLE MATH UFE Project distributed a monograph and presented at the annual meetings of the Psychology of Mathematics Education–NA Chapter, the Association of Mathematics Educators, state, national and regional meetings of NCTM and its affiliates, the North Carolina Mathematics Association of Two Year Colleges, the Annual Meeting of the Research Advisory Committee of the NCTM and the SIG-RME of the American Educational Research Association, and the joint meeting of the Mathematics Association of America and the American Mathematical Society.

The proposed project builds on the success of this NSF-funded Faculty Enhancement effort in three ways. (1) The model used to inform and prepare faculty for implementing change will be used during a weeklong, intensive, foundation-building workshop. (2) The courses being developed in the proposed project are directly related to the needs identified by the faculty who participated in the faculty enhancement project. (3) The courses, which were developed for undergraduate teacher preparation, will serve as models for the graduate courses being developed as part of the proposed project.

NCM<sup>2</sup> also benefits from the funding NSF provides in support of the MIDDLE MATH Curriculum Research and Development Project (DUE-9752659). The course development funded by this project provides the cornerstones for East Carolina University's middle grades mathematics teacher preparation program. This program has recently been recognized as one of eight national semi-finalists for the U.S. Department of Education award for effective teacher preparation and is awaiting the November 3<sup>rd</sup> announcement of the award winners. The team approach to the development of the undergraduate mathematics curricula and the blend of content and pedagogy modeled in these courses are reflective of the efforts to be extended in the proposed project.

### ***Statement of Need***

The recent report of the John Glenn Commission (The National Commission on Mathematics and Science Teaching for the 21st Century, 2000) provides two core premises that undergird every change the commission recommended and lie at the heart of the proposed NCM<sup>2</sup> project:

- 1. Now, more than ever, America's students must improve their performance in mathematics and science. That is the burden of the case presented thus far.*
- 2. The second premise points in the direction of a solution: The most direct route to improving mathematics and science achievement for all students is better mathematics and science teaching. In other words, better teaching is the lever for change.*

On the last NAEP math assessment, North Carolina's fourth graders performed above the national average, posting the highest gain in the nation on the 1996 mathematics results. (Tied with Texas.) Eighth-graders' NAEP math scores for 1996 showed the highest gain in the nation since 1990 and the second-highest gain since 1992, and their scores were well above the average in the Southeast and near the national average.

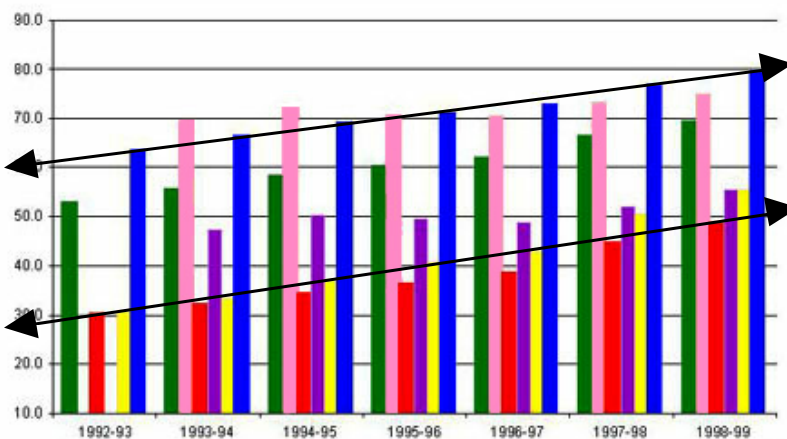
In its 1998 Report, The National Education Goals Panel identified North Carolina as the state showing the most significant improvement during the 1990s, by increasing its performance on 14 measures. The Panel called North Carolina's improvements, which led all states in the combined gains in math and reading achievement on NAEP between 1990 and 1996, "significant and sustained" with large achievement gains occurring for white, black and Hispanic students.

Michael E. Ward, North Carolina's State Superintendent and Phillip J. Kirk Jr., Chairman of the North Carolina State Board of Education (2000) attributed these gains to the ABCs and the Student Accountability Standards (The ABCs of Public Education is a state plan to reorganize public education in North Carolina through a rewards and accountability system built on statewide testing). North Carolina continues to receive recognition and accolades for the progress we are making in improving the achievement of all students. But despite the success, Ward warned of a hidden problem. "While we are very proud of all that has been accomplished, there is a great deal more that must be done to meet the needs of minority and at-risk students."

A casual glance at Table 1 shows the increase in performance made by North Carolina's grade 3 to 8 students on the End-of-Grade Math exams from 1993 to 1999. A second look shows the nearly parallel gains in the performance of the White and Black students over this seven year period.

Table 1 - Percentage of Students at/above Grade Level in EOG Math for North Carolina Students--Grades 3 to 8 through 1993-1999

Legend: ■ All Students ■ All Hispanics  
■ All Asian Students ■ All Indians  
■ All Blacks ■ All Whites



After seven years, the disparity between the End-of-Grade scores of the Black and White students has remained constant. While this is more likely evidence of a socio-economic, rather than an ethnic disparity — the need to close the achievement gap is critical. After seven years of efforts to improve students test scores, only half of the Black, Hispanic, and Native American students in North Carolina are performing at or above grade level.

Overall, student achievement is up in North Carolina and fewer students are performing at the lowest level of achievement. However there are serious disparities in performance among groups. For mathematics grades 3-8, 44.7 percent of Black students, 50.4 percent of American Indian students and 52 percent of Hispanic students performed at Achievement level III or above (Level III is considered to be at grade level) while 76.7 percent of White students were at Achievement level III. The disparity in performance in the rural northeastern part of the state is representative of the problem facing the state and the nation. Beaufort County is located 136 miles south of Norfolk, Virginia and 105 miles east of Raleigh. Its largest city is Washington with an estimated population of 10,000. The ethnic mix in P.S. Jones Middle School, the largest middle school in the Beaufort County Schools is 50 percent White, 47 percent Black, and 3 percent others (50 per cent of the Beaufort County students are eligible for Free/Reduced Lunch). Approximately 1/3 of the P. S. Jones eighth graders are enrolled in algebra. Of these students *only 5 percent* are non-white. On the 1999 Eighth Grade End-of-Grade Mathematics Test in Beaufort County, 59 percent of the Black students, 66 percent of the Hispanic students, and 86 percent of the White students performed at or above grade level. (The NC Eighth Grade End-of-Grade Test assesses students' achievement in the seven strands of the state's mathematics curriculum: numeration, geometry, patterns and pre-algebra, measurement, problem solving, data analysis and statistics, and computation. The test contains two parts, a computation section and an applications section.)

The U.S. Department of Education recently published results of the Third International Mathematics and Science Study (TIMSS). The mathematics results indicated that our eighth graders score below the international average of 41 TIMSS countries. TIMSS also included a large-scale observational study of eighth grade mathematics teaching in Japan, Germany, and the U.S. in an effort to identify factors associated with student performance. Its findings revealed pedagogic inconsistencies in U.S. mathematics teachers that may, in part, impact on student performance:

1. Japanese teachers widely practice what the U.S. reform recommends, while U.S. teachers do so less frequently.
2. Japanese teachers have more opportunities to discuss teaching-related issues than do U.S. teachers.

If students in North Carolina are to achieve world-class standards in mathematics, they must have teachers who can effectively use the latest strategies and resources in promoting the problem-solving approaches that underlie the North Carolina Curriculum.

The National Commission on Mathematics and Science Teaching for the 21st Century (2000) describes teaching as "at the core for educational change":

*...[A]fter an extensive, in-depth review of what is happening in our classrooms, the Commission has concluded that the most powerful instrument for change, and therefore the place to begin, lies at the very core of education—with teaching itself....We are of one mind in our belief that the way to interest children in mathematics and science is through teachers who are not only enthusiastic about their subjects, but who are also steeped in their disciplines and who have the professional training—as teachers—to teach those subjects well. Nor is this teacher training simply a matter of preparation; it depends just as much—or even more—on sustained, high-quality professional development.*

Research on mathematics reform identifies three critical areas of need: comprehensive professional development; accessible resources, information and technical assistance; and broad-based support.

**1. Comprehensive Professional Development.** Mathematics teachers have indicated the need for intensive professional development consistent with the best practices in curriculum, instruction, and assessment. Such a demand requires a comprehensive response encompassing a variety of elements, including: models of effective classroom techniques, enhanced understanding of mathematics content, and the flexibility to adapt professional development offerings to the demands placed on the individual teacher.

**Models.** Teachers are being asked to teach in ways that differ profoundly from those that they themselves experienced as students or learned in their pre-service coursework. As noted in the TIMSS findings, although U.S. teachers report an awareness with reform recommendations, few present a working knowledge of how to effectively implement the unfamiliar techniques in the classroom. The Office of Technology Assessment publication, *Teachers and Technology: Making the Connection* (1995), has offered a possible explanation for this inconsistency: "research has suggested that teachers learn best, not from one-shot lectures by experts, but by seeing methods used in the classroom, by trying out new techniques and getting feedback on their efforts, and by observing and talking with fellow teachers." In the *Principles and Standards for School Mathematics*, the NCTM (2000) goes further in describing the role higher education faculty should play in support of the professional development of teachers, "Faculty members in institutions of higher education should be partners in the development of school-based mathematics communities. Teacher educators, mathematicians, and practicing teachers working together can create a rich intellectual environment that will promote veteran teachers' growth and demonstrate to new teachers the value of learning communities (p. 370)."

**Content.** The 1998 revision of North Carolina Curriculum has increased the emphasis on the areas of mathematics content that the students should know. Many teachers are discovering that their pre-service and in-service education failed to provide them with the background in substantive areas of mathematics. The three NCM<sup>2</sup> courses highlight the mathematical content involved, as well as the pedagogy. For example, one course focuses on the teaching and learning of geometry and measurement—two areas that have proven to be significantly troublesome for North Carolina's middle school students.

**Flexibility.** The competing demands on middle school teachers can cause even those with the best intentions to forego valuable opportunities for professional development. Teachers need alternatives to traditional programs of university courses and workshops. While there is no easy way to complete graduate level coursework, efforts are made to make the classes easier to participate in. Classes are offered five weekends per semester. Further the courses will be offered

with consideration for the teachers schedule (for example, school breaks are considered when scheduling classes). The three graduate level *school mathematics* courses will be included in both the ECU MAEd in Mathematics and the MAEd in Middle Grades Education. Two additional courses from ECU's Graduate Program (*Leadership in Mathematics Education* and *Assessment in the Mathematics Classroom*) will be made available to NCM<sup>2</sup> teachers tuition free through summer distance ed. offerings. Depending on approval by the participating universities, teachers will be able to apply the courses to a Master's Degree at their local institution or at ECU.

**2. Access to Resources, Materials, and Technical Assistance.** Teachers have expressed the need for convenient and timely access to information and resources that would help them expand their knowledge of mathematics, of research on the teaching and learning of mathematics, of new pedagogical practices, and of instructional resources. Interaction with colleagues is especially important to teachers whose daily schedules with students leave almost no time for intellectually engaging, thoughtful dialogue with peers on issues of teaching and learning mathematics. The teacher-fellow interaction will help teachers find ways to utilize what they learn in the courses. To maximize the value of learning to use manipulatives or computer applications in the study of mathematics, teachers must be able to try things with their children.

**3. Broad-based Support.** Teachers need to believe that there is strong administrative support for modifying the way they teach. The dialogue becomes more meaningful by having a common vocabulary and feeling of intent at the state, regional, and local levels. Support from parents will be enhanced when the school administration can articulate the changing nature of middle school mathematics. The lessons learned by the NCM<sup>2</sup> teachers in the middle grades classroom will become a valued component of their professional development.

Meeting the goal of providing a sound mathematics education for all students requires a teaching force with a higher level of professional preparation and commitment to on-going professional development. A 1998 Harris Poll revealed that roughly nine out of ten Americans believe the best way to lift student achievement is to ensure a qualified teacher in every classroom. In response, states are mandating higher standards for teacher certification as well as for student achievement. Teacher preparation efforts at institutions of higher education are being monitored closely.

North Carolina is representative of the national quest for higher teaching standards and in many ways leads the nation in this regard. In 1996, the state legislature established the North Carolina Professional Teaching Standards Commission with the charge of establishing high standards for North Carolina teachers and the teaching profession. The North Carolina Excellent Schools Act (1998) required all masters of education programs qualifying teachers for graduate licensure to be significantly revised. An approved master's degree must "*extend the new teacher standards of the Interstate New Teacher Assessment and Support Consortium (INTASC) and the NCDPI competencies currently required for initial "A" licensure in the student's teaching area; [and] in addition, build on the curriculum standards of national specialty area associations, the standards of the National Board for Professional Teaching Standards, and the NCDPI guidelines currently required for a "G" [graduate] license in the student's teaching area.*" These new master's degree programs (to become available later this year) are to "*involve experienced teachers, university faculty, and other practicing educators in the design of the curriculum.*"

In support of these efforts to improve the quality of teaching, the legislature provided significant financial rewards. Teachers who obtain National Board certification receive a minimum 12% salary increase. Teachers who complete the new master's degree receive a minimum 10% salary increase.

Ironically, the national call for higher teaching standards coincides with a time of severe shortages in the number of qualified teachers. Hiring and retaining certified middle school mathematics teachers is a major problem for nearly all North Carolina school districts. Non-certified teachers fill an estimated 20% of the positions. This problem is magnified by the number of middle school mathematics teachers holding elementary (K–6) licenses, which require only three hours of post-secondary coursework in mathematics. At the same time the state is attempting to improve the teaching force, it has mounted a parallel move to hold students to a higher level of expectation for graduation. The new requirement that all students must pass an eighth grade end-of-grade test and an algebra I end-of-course test for high school graduation has increased the demands on the preparation of middle school mathematics teachers.

In helping schools and districts meet these challenges, NCDPI has been hampered by the lack of a strong leadership group in middle school mathematics. At the high school level, NCDPI supports a network of department chairs, which serves as a source of assistance and a channel for dissemination. At the elementary level, the NSF-supported TEAM Project (ESI-8850940) developed a corps of experienced and capable teachers to whom the department turns for assistance with curriculum revision, testing, and professional development. There is no comparable leadership group at the middle school level. The NC Department of Public Instruction has committed to providing the financial support needed to include the middle school teachers on the NCM<sup>2</sup> Leadership Network in the annual mathematics retreat for high school department heads, both during *and after* the completion of the project.

## ***Goals and Objectives***

NCM<sup>2</sup> addresses three crucial needs in North Carolina's middle school mathematics instruction:

### ***1. Retention, Recognition, and Renewal***

NCM<sup>2</sup> provides a vehicle for coordinating a statewide effort to help teachers realize the financial rewards the state is prepared to provide in support of their professional development and to assure that the teaching and learning of mathematics improves. NCM<sup>2</sup> meets this goal by building on an established statewide infrastructure for promoting professional development opportunities. Established by the legislature in 1984, the UNC Mathematics and Science Education Network is comprised of ten mathematics and science education centers located on various UNC campuses across the state. Nine of these centers will participate in this project, including the centers at Appalachian State University, East Carolina University, Fayetteville State University, North Carolina State University, UNC Chapel Hill, UNC Charlotte, UNC Wilmington, and Western Carolina University. The ninth center is the Greensboro Area Mathematics and Science Education Center, a joint project of North Carolina A&T State University and UNC Greensboro. The Network has successfully managed several statewide NSF-sponsored projects, including the mathematics project TEACH-STAT: Teaching Statistics Grades 1–6 (ESI-9153779).

The NCM<sup>2</sup> Leadership Network will develop a series of three graduate-level courses for middle school mathematics teachers, one each in the content areas of statistics and data analysis, geometry and measurement, and number and algebra. The MSEN centers will provide these courses to a total of 135 teachers statewide (15 teachers in each of the nine regions). The teachers will use this course work in obtaining National Board Certification in Early Adolescence/Mathematics and as the foundation for obtaining master's degrees in middle school mathematics education. Project classes will be offered during the academic year to enable teachers to complete additional degree coursework in the summers. Funding will be provided to support the tuition costs for courses completed during the project. North Carolina teachers achieving both these career steps are eligible for salary increases of nearly 25%. As reported by the National Commission on Mathematics and Science Teaching for the 21st Century (2000) "the number one reason for dissatisfaction among mathematics and science teachers is "poor salary"—cited by 66% of those who leave their jobs."

The NCM<sup>2</sup> project will support teacher retention in several ways:

- Improving teachers' content and pedagogical knowledge. The three NCM<sup>2</sup> courses will improve the teachers' confidence and skill in the classroom. The pedagogical component of the courses will be aimed at helping teachers learn how to address the mathematical needs of all their students, reducing the frustration many teachers now feel at their inability to bring all students to acceptable levels of performance.
- Helping teachers articulate their goals and receive credit for their accomplishments as they seek National Board certification. Achievement of the certification carries a 12% salary supplement and brings the teachers a measure of recognition within their schools and school systems. The mentoring of National Board Certified Teachers (through workshops, classes, and the listserve) will support teachers in this effort.
- Launching teachers on a long-term program of professional development by getting them started on master's degrees at one of the participating universities. Starting a master's

degree represents a significant commitment to the profession, recognized in North Carolina by advanced licensure and an additional salary supplement.

## **2. School and District Level Leadership**

The NCM<sup>2</sup> teachers will model standards-based teaching, serve as mentors for other novice teachers, and provide professional development opportunities for their peers.

## **3. State Level Leadership.**

The National Commission on Mathematics and Science Teaching for the 21st Century (2000) noted the need for leadership training to prepare teachers for the role of facilitators and mentors in the support of change:

*Summer Institutes and Inquiry Groups must be facilitated by teachers who are current with the most effective teaching methods in their disciplines, who have shown demonstrable results of higher student achievement in mathematics and science, and who are adept in the use of technology for teaching and learning. Although there are many such teachers, the demand far outpaces the supply. To remedy this, many more potential leaders must be identified and trained.*

The NCM<sup>2</sup> Leadership Network will combine teams from each MSEN center including university mathematicians, university mathematics educators, school district administrators, and highly qualified middle school mathematics teachers (two teachers from each center). The Leadership Network will assist NCDPI in:

- Revision of the North Carolina Standard Course of Study, the state-mandated curriculum (scheduled to be revised by 2003);
- Corresponding revision of the state tests, including End-of-Grade Tests and the End-of-Course Test for Algebra I; and
- Assisting the State Textbook Commission in selecting instructional materials for adoption by schools and districts. (Although schools are not required to select from the state list, the failure of the Commission to select any of the NSF-supported middle school curricula in the last cycle (1997-98) is a substantial hindrance to improvement of middle school mathematics in the state).

## ***The Plan of Operation***

To meet the goals of the project, the NCM<sup>2</sup> Leadership Network will be divided into three regional triads—western, central, and eastern. One team from each triad will work together on the design of a graduate-level *school mathematics* course. In all, three *school mathematics* courses will be created—statistics and data analysis, geometry and measurement, and number and algebra. The courses will be designed to address a need expressed by the National Council of Teachers of Mathematics in the *Professional Standards for Teaching Mathematics* (1991)—“Teachers need opportunities to revisit school mathematics topics in ways that will allow them to develop deeper understandings of the subtle ideas and relationships that are involved between and among concepts (p. 134).”

The importance of *school mathematics* courses is further articulated in the March 2000 Draft of the CBMS Mathematical Education of Teachers Project Report:

*There is much evidence of a vicious circle in which too many future teachers enter college with serious holes in their understanding of school mathematics, have little college instruction focused on the mathematics they will teach, and so enter their classrooms inadequately prepared to teach mathematics. College mathematics courses should be preparing teachers to learn much of the mathematics they will need to know in the future rather than trying to cram everything they need into their college education. Teachers need to learn how fundamental mathematical principles underlie classroom practice, so that they can teach mathematics as a coherent, reasoned activity and communicate an appreciation of the elegance and power of mathematics. With such knowledge, they can effectively*

*respond to variations in standard procedures that students may create. Courses developing this knowledge should make frequent connections between the mathematics being studied and classroom practice.”*

Collaboration between the mathematics and mathematics education faculty, school administrators, and 6-8 teachers will ensure that the courses being developed include a multi-dimensional approach to meet the learning needs of middle grades teachers. A weeklong foundation building workshop will provide a common set of shared experiences for the NCM<sup>2</sup>. Consultants from in-state and out-of-state will present interactive experiences reflecting on the current resources relevant to the curriculum development effort; e.g. *Knowing and Teaching Elementary Mathematics* by Liping Ma; the NCTM PSSM, the CBMS Report, the TIMSS studies of teaching and learning, and the Middle Math Monograph. A workshop on the NSF-funded middle grades standards-based curricula and a review of the professional development needs noted by the project directors as important for supporting their implementation will be included. Representatives from North Carolina’s LSC’s will be invited to share implementation stories. Three of North Carolina’s National Board Certified teachers will introduce the leadership team to the challenges of becoming board certified and ways in which the courses can help teachers meet this goal.

Initial course outlines and planning will be done with the full participation of the team members. Courses will then be designed by the university faculty and offered to the administrators and teachers. The classes will be team taught with each faculty member rotating instruction on an hourly basis. This is important, not as a model for curriculum development, but because it will force the team to discuss how to present the problems, what mathematics could be brought out using the problems, and (after class) what was accomplished and how it could have been done more effectively.

The middle school teachers on the leadership team will complete all course assignments and receive graduate credit for completing the courses. They will maintain journals with reference to the problems for which they needed hints. Their notes will guide revision of the course materials prior to statewide offering. During the academic year, the teachers will videotape classes in large-group and small-group settings. Clips from the videos will be used in the final revision of the course. Finally, those middle school teachers in the Leadership Network who have not already done so will complete the National Board content assessment and portfolio assessment. Final revision of the courses will rest heavily on the teachers’ interpretation of how well they support the successful completion of the process. Our National Board Certified consultants will provide additional support for teachers completing this process. Beyond assisting the faculty in the development of the courses, the consultants will assist the PI’s in the development of a website and a private listserv.

In the subsequent course offerings to the 135 NCM<sup>2</sup> teachers, the instructional staff will include the six NCM<sup>2</sup> Leadership Team middle school teachers from their regional triad and one of the faculty members. In the class, teachers will take a reflective look at middle grades mathematics content to deepen their understanding of the specific content and the interconnections between the nature of the content and the teaching and learning of the content. This reflective look at middle school mathematics will be linked to the middle school classroom via examples of students’ work, middle school curricula and research on learning. The class will be taught in an interactive manner with an emphasis on problem solving and reasoning. The content of the three courses will be Number and Algebra, Statistics and Data Analysis, and Geometry and Measurement.

Rather than use a textbook, teachers will work on problem sets and new topics will be introduced through the class discussion of the problems. The courses will focus on the processes students use to learn to solve problems. The assignments will be designed to promote the development of conceptual understanding over time. Each topic will be developed over the course of several problem sets. Each problem set will include problems from middle school student materials, real world applications, skills development, analysis of student errors, a reading assignment which is often tied to research on student learning or research on teaching, and a writing or journal assignment. Teachers will video samples of lessons they present in whole-class and small-group settings. At the end of each course, teachers will turn in a portfolio (in the spirit of a National Board’s portfolio) demonstrating their progress.

Lessons in the three NCM<sup>2</sup> courses will focus on standards-based middle school mathematics reform. Activities and classroom assignments will be utilized to deliver key messages and to initiate reflection and analysis of teaching and learning. The courses will be a valuable resource for teachers contemplating change from a traditional middle school curriculum to one consistent with the vision of the NCTM *Principles and Standards for School Mathematics* (PSSM 2000).

Each course will be designed to emphasize five “big ideas” as well as the process standards (NCTM, 2000) of problem solving, communication, reasoning and proof, representation and connections. The ideas are:

- 1) reflection on acquired knowledge—how students come to know,
- 2) ties to the middle school classroom—how new disciplinary knowledge can be incorporated in curriculum development,
- 3) tools for learning—how technology can be used to advance teaching,
- 4) research on student learning and research on teaching—how teaching and learning can be assessed, and
- 5) reflection on pedagogy—how scientific knowledge and the process of inquiry can be communicated to diverse novice learners in a variety of settings.

The creation of course materials will be an outcome of the collaboration of NCM<sup>2</sup> Leadership Team. We are therefore unable to provide samples of the problem sets here. However, since this project is an outgrowth of a similar collaboration on the creation of undergraduate curricula, the nature of the problem sets may be inferred from the nature of the problem sets created for the NSF-funded MIDDLE MATH Undergraduate Curriculum Research and Development Project. The problem sets created for an undergraduate course on number and algebra parallel to the graduate course proposed here are available for review at <http://www.math.ecu.edu/midmath>.

The team in the regional triad that participated in its development will offer each course. Statewide offerings will be staggered to enable the teams to refine the courses over the duration of the project. The grid below gives one possible model for how this will be accomplished:

	Western Triad	Central Triad	Eastern Triad
Fall 2002	Statistics/data analysis Dr. Nick Norgaard WCU	Geometry/measurement Dr. Kathy Cousins-Cooper NCA & T	Number/algebra Dr. Heather Ries ECU
Spring 2003	Geometry/measurement Dr. Dee Wasman ASU	Number/algebra Dr. Russ Rowlett UNCH	Statistics/data analysis Dr. Kenneth Jones FSU
Fall 2003	Number/algebra Dr. David Pugalee UNCC	Statistics/data analysis Dr. Hollylynne Drier NCSU	Geometry/measurement Dr. Ann Crawford UNCW

The courses will serve as a valuable resource for teachers contemplating change from a traditional middle school curriculum to one consistent with the revised North Carolina Mathematics Curriculum. The proposed project will provide the participating teachers with the appropriate resources necessary to implement the instructional models provided in class. Whenever instruction with manipulatives or computer software is modeled, the teachers will have sufficient quantities of the learning tools to try the lessons with their students.

Detailed descriptions of the plan for attaining the project’s leadership goals are included in the following timeline.

***Timeline:***

- YEAR 1**  
*Summer 2001.* Identify NCM<sup>2</sup> Leadership Team including one district level administrator and two middle school mathematics teachers with strong leadership potential.  
 Week 1: NCM<sup>2</sup> Leadership Network meets for a foundation-building workshop including PSSM, NSF middle school curricula, MAA Guidelines. The week ends with the course development teams drafting course outlines.  
 Weeks 2-3: The three University faculty meet to design the materials planned

for use in the courses.

Weeks 4-5: *Statistics and Data Analysis* is taught to the middle grade teachers and school system administrators.

Fall  
2001.

*Number and Algebra* is taught on five weekends (one every 4 weeks). The NCM<sup>2</sup> Leadership Network meets at the NC Council of Teachers of Mathematics (NCCTM) annual meeting. One of the weekend sessions will be conducted at the close of that meeting.

MSEN Centers identify districts willing to support NCM<sup>2</sup> teachers' participation.

MSEN Centers recruit 15 teachers from these districts willing to commit to the completion of the project and the National Board Certification Process.

Spring  
2002.

*Geometry and Measurement* is offered on five weekends (one every four weeks). The middle school teachers on the NCM<sup>2</sup> Leadership Team who have not already done so complete the National Board Portfolio Assessment.

**YEAR 2**  
Summer  
2002.

NCM<sup>2</sup> Leadership middle school teachers complete the National Board Content Assessment. The NCM<sup>2</sup> Leadership Network meets for one week to revise courses. The NCM<sup>2</sup> Leadership Network and NCM<sup>2</sup> Teachers join in a distance-education offering of an *Introduction to the Project* (1-day).

Fall  
2002.

One course offered in each triad. The NCM<sup>2</sup> Leadership Network participates in the NCCTM annual meeting and attends the NCCSM (NC Council of Supervisors of Mathematics) sessions. They begin serving on NCDPI committees. Support is provided for project teachers to participate in the NCCTM annual meeting and a meeting of all NCM<sup>2</sup> teachers is held after the NCCTM meeting—Friday and Saturday. This session supports teachers' planning for completing National Board certification.

MSEN Centers serve as a liaison with the districts for the project's evaluation team in the collection of student data and to arrange classroom visitations.

MSEN Centers work with districts and private industry to find professional development funding to support teachers in the completion of additional coursework leading to a master's degree.

Spring  
2003.

The NCM<sup>2</sup> Leadership Network participates in NCCTM regional meetings. They serve on DPI committees. One course is offered in each of the triads.

Work with districts to establish ways in which NCM<sup>2</sup> teachers' may assume local leadership; e.g., as mentors, establishing model teaching sites, working for the districts during the summer on the creation of support materials for the districts mathematics instruction or serving on text book adoption committees.

MSEN Centers continue serving as a liaison with the districts for the project's evaluation team in the collection of student data and to arrange classroom visitations.

MSEN Centers continue working with districts and private industry to find professional development funding to support teachers in the completion of additional coursework leading to a master's degree.

**YEAR 3**  
Summer  
2003.

NCM<sup>2</sup> teachers receive ECU tuition waivers for a distance ed. offering of MATH 6206 "Leadership in Mathematics Education" to extend their NCM<sup>2</sup> coursework to additional graduate coursework leading to a master's degree.

Fall  
2003.

One course is offered in each of the triads. The NCM<sup>2</sup> Leadership Network participates in the NCCTM annual meeting and attends the NCCSM sessions. They serve on DPI committees. The NCM<sup>2</sup> Leadership Network and project teachers attend the NCCTM annual meeting and a special extended workshop after the NCCTM meeting—Friday and Saturday. The workshop includes planning for completing the National Board certification process.

- Spring 2004.* The NCM<sup>2</sup> Leadership Network participates in NCCTM regional meetings. They serve on DPI committees. NCM<sup>2</sup> teachers complete their portfolios as required by the National Board. A list serve will be established to support teachers during these efforts. NCM<sup>2</sup> teachers working towards a master's degree receive tuition support to complete one additional course in their program.
- MSEN Centers work with districts to establish ways in which the NCM<sup>2</sup> Leadership Team and the NCM<sup>2</sup> teachers' may assume local leadership; e.g., as mentors, establishing model teaching sites, working for the districts during the summer on the creation of support materials for the districts mathematics instruction or serving on text book adoption committees.
- MSEN Centers arrange and facilitate a two-day follow up workshop at the center lead by the NCM<sup>2</sup> Leadership Team for the NCM<sup>2</sup> teachers.
- YEAR 4**  
*Summer 2004.* NCM<sup>2</sup> teachers complete their content assessment as required by the National Board. The listserv supports teachers in these efforts. NCM<sup>2</sup> teachers receive ECU tuition waivers for a distance ed. offering of MATH 6200 "Mathematics Assessment for the Classroom Teacher" to extend their NCM<sup>2</sup> coursework to additional graduate coursework leading to a master's degree.
- Fall 2004.* The NCM<sup>2</sup> Leadership Network participates in the NCCTM annual meeting and attends the NCCSM sessions. They serve on DPI committees. All participants attend the NCCTM annual meeting and a special extended workshop after the NCCTM meeting—Friday and Saturday. This session suggests ways to improve the program based on the assessment and portfolio experiences. Next steps in the professional development process are explored. NCM<sup>2</sup> teachers receive tuition support to extend their course work to one graduate course leading to a master's degree.
- MSEN Centers work with districts to establish ways in which the NCM<sup>2</sup> Leadership Team and the NCM<sup>2</sup> teachers' may assume local leadership; e.g., as mentors, establishing model teaching sites, working for the districts during the summer on the creation of support materials for the districts mathematics instruction or serving on text book adoption committees.
- MSEN Centers arrange and facilitate a two-day follow up workshop at the center lead by the NCM<sup>2</sup> Leadership Team for the NCM<sup>2</sup> teachers.
- Spring 2005.* The NCM<sup>2</sup> Leadership Network participates in NCCTM regional meetings. They serve on DPI committees. They meet to evaluate the project and set next steps. NCM<sup>2</sup> teachers receive tuition support to extend their NCM<sup>2</sup> teachers course work to one graduate course leading to a master's degree. Special workshops and online support are provided to any teachers who were unsuccessful in one or more components of the National Board evaluation.
- MSEN Centers arrange and facilitate a two-day follow up workshop at the center lead by the NCM<sup>2</sup> Leadership Team for the NCM<sup>2</sup> teachers.
- A final report is prepared and submitted to NSF.
- If necessary, teachers retake the content portion of the National Board Certification process. A no-cost extension will be requested if it is necessary to complete the project in the summer.

### ***The administrative team***

The principal investigators for the NCM<sup>2</sup> project include:

*Dr. Russell J. Rowlett* has been the Director of the Center for Mathematics and Science Education (CSME) at UNC Chapel Hill since 1987. After receiving his Ph.D. in mathematics from Virginia, he was Assistant/Associate Professor of Mathematics at the University of Tennessee for 13 years. As Director, he has received more than \$4.3 million in grants in support of teacher professional

development and student enrichment projects in both mathematics and science. He is the lead PI of the North Carolina Leadership Network for Earth Science Teachers (ESI-9355614) and of the planning grant for this project (ESI-9814062) and leads an NSF-supported planning effort (ESI-9814062) for a Local Systemic Change project in Chatham County, North Carolina. He is also the PI on two current Eisenhower grants, one helping middle school teachers apply national mathematics standards and one helping teachers of grades 3-8 integrate technology in science and mathematics education. NSF funding in support Dr. Rowlett's time on the project will be matched by CMSE.

*Dr. Sid Rachlin* is Professor of Mathematics Education at East Carolina University. Sid has extensive experience in directing externally funded projects, having been funded by the NSF, US Department of Education, National Institute of Education, McNerny Foundation, the Bell South Foundation, the National Center for Research in Mathematical Sciences Education, and the Research Corporation of the University of Hawaii. He is currently Project Director and co-PI of the nearly completed MIDDLE MATH Curriculum Research and Development Project (DUE-9752659). He headed the MIDDLE MATH UFE Project (DUE-9455152) at ECU that brought 40 other mathematicians and mathematics educators together to work collaboratively to develop models for the mathematics component of middle grades teacher preparation programs. He will be the lead person in developing MATH 5263, a graduate course on *Algebraic Concepts and Relationships*. East Carolina University will match NSF funding to support Dr. Rachlin's time on the project.

*Dr. Henry Johnson* is Associate Superintendent, Instructional and Accountability Services, NC Department of Public Instruction. His section is responsible for the revision of the state curriculum in mathematics, coordinates professional development activities, and manages accountability, testing, and school improvement. The NC DPI will contribute 5% of Dr. Johnson's time to support the project.

*Dr. Gerry Madrazo* is Executive Director of the UNC Mathematics and Science Education Network and a science educator. He will be responsible for helping coordinate of the activities of the MSEN centers. The MSEN will contribute 5% of Dr. Madrazo's time to support the project.

## ***Evaluation***

The evaluation of NCM<sup>2</sup> will be based on three types of evidence. Formative evidence demonstrates that NCM<sup>2</sup> gathers and uses data to make adjustments to the various stages of the program. Summative evidence demonstrates the effectiveness of the overall project in helping NCM<sup>2</sup> teachers acquire the content knowledge, pedagogical knowledge and skills, and beliefs about learners and teaching as a profession needed to improve *all* students' learning.

Since a major goal of the project is to support middle school mathematics teachers through the National Board Certification process, the project will be accountable for the success teachers have in reaching that goal. The portfolio and content assessments of the 135 teachers will provide a clear measure of the program's success. While the project will not require participants to complete their master's degrees, it will provide significant support and encouragement for this to occur. A reasonable expectation is that 1/3 of the teachers will accomplish this objective.

A second summative measure of the success of the project is the degree to which we meet or exceed this goal. Follow-up questionnaires and interviews with teachers who did not pursue a master's degree or who did not complete the process will reveal how the project could have been modified to increase the number of teachers reaching this goal.

Another goal of the project is to provide a statewide leadership pool. The success of the project in reaching this goal will be revealed by a database of the professional activities of the NCM<sup>2</sup> Leadership Network over the course of the project.

Confirming evidence, the third form of evidence used to evaluate the project, will reflect the effectiveness of NCM<sup>2</sup> teachers in helping *all* students improve their learning in mathematics at the middle school level and the extent to which the teachers are assuming roles as school and district leaders. For the project to be successful, it must have a positive effect on student performance. Site visits will be conducted by the external evaluator to verify information presented in teachers'

portfolios and classroom videos. Student achievement will be measured by their end-of-grade test scores and comparisons will be made between the scores for students in NCM<sup>2</sup> teachers and the students of other teachers in their schools.

Dr. Edwin C. McClintock, Florida International University will serve as the external evaluator for the project. Dr. McClintock has extensive experience in the evaluation of large-scale collaborative professional development programs. For example, the Los Angeles Collaborative for Teacher Excellence (LACTE) involved ten community colleges, four-year colleges and universities in the Los Angeles area with a unified plan, a shared vision, and four important goals and related objectives. For the evaluation of NCM<sup>2</sup>, Dr. McClintock recommends a validation model. Evidence will be gathered from multiple sources, both quantitative and qualitative. Even though the evidence might not have been developed from a research process, we will consider the same issues that ensure confidence in research results in identifying credible evidence to support claims of effectiveness. For example, anecdotal evidence lacks credibility unless it is obtained through a systematic process. Threats to validity include lack of a representative sample and response bias due to a lack of anonymity.

Internal evaluation for NCM<sup>2</sup> will be coordinated through the NC State University Mathematics and Science Center. Under the direction of Sarah Berenson, this research center is charged with the evaluation of MSEN initiatives. The project will provide a graduate student to assist the NC State Center Director and the Project Manager in the collection of evidence. Dr. Berenson will contribute the equivalent of one annual month to the internal evaluation effort.

Core evaluation questions include:

1. What is the overall quality of the NCM<sup>2</sup> professional development activities?
2. What is the extent of school and teacher involvement in NCM<sup>2</sup> activities?
3. What is the impact of the NCM<sup>2</sup> professional development on teacher preparation, attitudes, and beliefs about mathematics education?
4. What is the impact of the NCM<sup>2</sup> professional development on classroom practices in mathematics (pedagogy)?
5. How sustainable are the NCM<sup>2</sup> reforms?

Strategies/methodologies for answering the core evaluation questions will include: professional development observations (8 per year)—selected activities; classroom observation (10 per year)—random sample of project teachers; individual teacher interviews (10 per year)—random sample of treated teachers; principal questionnaires (entire population each year)—all principals of NCM<sup>2</sup> teachers; longitudinal follow-up of students who were impacted by the NCM<sup>2</sup> to chronicle enrollment in and completion of upper level mathematics courses during high school; increases in numbers of teachers who completing national board certification in middle grades mathematics; and increases in the retention rate of treated teachers.

Additional evaluation questions include:

6. Has the NCM<sup>2</sup> contributed to increases in mathematics achievement scores on end-of-grade tests?
7. Has the NCM<sup>2</sup> positively influenced the attitudes of students toward mathematics?
8. Has the NCM<sup>2</sup> resulted in increases in student knowledge in mathematics?

Strategies/methodologies for answering additional evaluation questions include: focus group interviews with teachers and students (3 for each center per year)—random sample from NCM<sup>2</sup> teachers; comparisons of baseline scores on end-of-grade mathematics tests to scores to treatment group scores for grades 6, 7, and 8 each year; finally, the evaluators will look for increases in the numbers of students enrolling in upper level mathematics classes as treated students begin to reach grade 7 and 8. In particular, we will be looking for increases in the number of minority students in algebra and pre-algebra.