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ABSTRACT

The Urban Mathematics Collaborative (UMC) project has the goal of contributing to the improvement of mathematics education in the inner-city schools by identifying models to enhance the professional lives of teachers and encouraging the entry of high school mathematics teachers into a larger mathematics community including mathematicians from higher education and industry. This document is a 5-year site report on the Cleveland Collaborative for Mathematics Education from its inception in 1985 through June 1990. The intent is to reflect on the development of the collaborative, noting the changes that have taken place in regard to the context in the collaborative operated, the collaborative's management structure, and the focus of its activities. This final site report addresses the major influences exerted on the collaborative and the directions the collaborative has taken. Some conclusions are reached regarding both the collaborative's development and achievements in light of its specific goals as well as the goals of the total UMC project. (MDH)

December 1991
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CLEVELAND COLLABORATIVE FOR MATHEMATICS EDUCATION (C^2ME)

FIVE-YEAR SITE REPORT

A Final Report to the Ford Foundation on the Urban Mathematics Collaborative (UMC) Project

Norman L. Webb, Susan D. Pittelman, Thomas A. Romberg, Allan J. Pitman, Edel M. Reilly, and James A. Middleton

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Report from the
Urban Mathematics Collaborative Documentation Project

Wisconsin Center for Education Research
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Madison, Wisconsin

December 1991

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I. INTRODUCTION

This document is a five-year Site Report on the Cleveland Collaborative for Mathematics Education (C^2ME) from its inception in 1985 through June, 1990. The intent is to reflect on the development of the collaborative, noting the changes that have taken place in regard to the context in which the collaborative operated, the collaborative's management structure, and the focus of its activities. It is not the intent of this report to review the development of the collaborative; this has been done in the annual reports. This final Site Report addresses the major influences exerted on the collaborative and the directions the collaborative has taken. Some conclusions are reached regarding both the collaborative's development and achievements in light of its specific goals as well as the goals of the total Urban Mathematics Collaborative project.

The Urban Mathematics Collaborative Project

In 1984, the Ford Foundation initiated the Urban Mathematics Collaborative (UMC) project to improve mathematics education in inner city schools and to identify new models for meeting the on-going professional needs of urban teachers. In February, 1985, the Foundation awarded five grants to establish urban mathematics collaboratives in Cleveland, Minneapolis-St. Paul, Los Angeles, Philadelphia, and San Francisco. In addition, the Ford Foundation established a Documentation Project at the University of Wisconsin-Madison to chronicle the development of the new collaboratives and a Technical Assistance Project (TAP) at the Education Development Center (EDC) in Newton, Massachusetts, to serve as a source of information for the collaborative projects (Romberg & Pitman, 1985). During the next 18 months, UMC projects were funded in Durham, Pittsburgh, San Diego, St. Louis, Memphis, and New Orleans, for a total of eleven collaboratives (Webb, Pittelman, Romberg, Pitman, Fadell, & Middleton, 1989). In August, 1987, an Outreach Project was funded at EDC to publicize and expand the UMC effort. In August of 1989, the Ford Foundation awarded replication grants to three additional sites: Dayton, Ohio; Columbus, Georgia; and Milwaukee, Wisconsin. In April, 1991, the fifteenth and final collaborative, the Greater Worcester Urban Mathematics Collaborative, was established in Massachusetts. A map indicating the location of UMC projects is presented in Figure 1.

The
Urban Mathematics Collaborative Project

Funded by The Ford Foundation

- **Cleveland Collaborative for Mathematics Education (C^2ME)**
  Cleveland, Ohio
- **Durham Collaborative The Durham Mathematics Council**
  Durham, North Carolina
- **Los Angeles Urban Mathematics/Science/Technology Collaborative (LAUM/S/TC)**
  Los Angeles, California
- **Memphis Urban Mathematics Collaborative**
  Memphis, Tennessee
- **New Orleans Mathematics Collaborative (NOMC)**
  New Orleans, Louisiana
- **Philadelphia Math Science Collaborative**
  Philadelphia, Pennsylvania
- **Pittsburgh Mathematics Collaborative**
  Pittsburg, Pennsylvania
- **St. Louis Urban Mathematics Collaborative**
  St. Louis, Missouri
- **San Diego Urban Mathematics Collaborative**
  San Diego, California
- **San Francisco Mathematics Collaborative**
  San Francisco, California
- **Twin Cities Urban Mathematics Collaborative**
  Minneapolis-St. Paul, Minnesota

Replication Sites

- **Columbus Regional Mathematics Collaborative (CRMC)**
  Columbus, Georgia
- **Dayton-Montgomery County Public Education Fund Mathematics Collaborative**
  Dayton, Ohio
- **Greater Worcester Urban Mathematics Collaborative**
  Worcester, Massachusetts
- **Milwaukee Metropolitan Mathematics Collaborative (M^3C)**
  Milwaukee, Wisconsin

Figure 1. The National Network of Urban Mathematics Collaboratives.

During the five years covered in this Site Report, mathematics education in the United States has changed. When the Ford Foundation initiated the UMC project in 1984, a consolidated effort to reform mathematics had not yet begun, although the potential of the mathematics education community for achieving reform was envisioned. In this regard, the UMC project was innovative in mobilizing a group of inner-city teachers to increase both their sense of professionalism and their connections with mathematicians in the business community and in higher education. Between 1985 and 1990, mathematics education in this country began to change dramatically. In an effort to develop a new mandate based on such studies as *Renewing United States Mathematics: Critical Resource for the Future* (Commission on Physical Sciences, Mathematics, and Resources, 1984) and *A Nation at Risk: The Imperative for Educational Reform* (National Commission on Excellence in Education, 1983), the Mathematical Sciences Education Board in 1989 issued *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* and the National Council of Teachers of Mathematics published *Curriculum and Evaluation Standards for School Mathematics*. As the collaboratives matured, the movement to change mathematics education in the country took on momentum, creating a new environment for the collaborative network. What began as a project designed to enhance the professional development of urban teachers evolved into a catalyst for the reform of mathematics education.

At each site, the UMC project supports collaboration among school mathematics teachers and between teachers and mathematicians from institutions of higher education and industry; it also encourages teacher membership and participation in a broad-based local mathematics community. Although the guiding principle behind the UMC effort has been that the teacher is and will remain at the hub of the educational process, it has become evident that many teachers--and especially those in inner-city schools--are overworked; lack support and material resources; and are isolated from their colleagues, from other professionals, and from the rapidly changing field of mathematics. Thus, the focus of the UMC project remains rooted in the premise that collegiality among professional mathematicians can reduce teachers' sense of isolation, enhance their professional enthusiasm, expose them to a vast array of new developments and trends in mathematics, and encourage innovation in classroom teaching.

Structure of the Five-Year Summary

The Five-Year Summary presented in the following chapter is comprised of six sections. The first section provides a brief overview of the collaborative. In the second section, the purpose of the collaborative is presented, as stated in its proposals to the Ford Foundation. The goals outlined in the collaborative's final request for funds to the Ford Foundation are contrasted with those specified in its initial proposal. The third section discusses the context within which the collaborative operated and the extent to which this has remained stable or has changed over the five-year period. Topics addressed in this section include demographic information on the surrounding community, changes in school district administration and enrollment and in the teacher population targeted by the collaborative, and significant changes occurring in mathematics and in the professional environment. The fourth section of the report describes the management structure adopted by the collaborative and changes that occurred in that structure over the five-year period. The fifth section covers the collaborative's activities in relation to four major themes that emerged from the documentation process as dominant in most collaboratives: socialization and networking, increased knowledge of mathematics content, teacher professionalism, and teacher leadership. These themes are used as a focus to organize ideas and to reflect on the collaborative's development with respect to some overriding expectations of the UMC project. The sixth and final section presents the reflections of Documentation Project staff on the approach the collaborative took to achieve its goals and the perceived outcomes in the areas of collaboration, professionalism, and mathematics focus.

The information presented in the Site Report is both a condensation and synthesis of information collected over the span of the UMC Documentation Project. Data were collected through monthly reports, the electronic network, four large-scale surveys, two demographic surveys, site visits, and case studies. These data-collection instruments and procedures are described in detail in the *UMC Guide to Documentation* (Pittelman, Webb, Fadell, Romberg, Pitman, & Sapienza, 1991). Detailed information about the Urban Mathematics Collaborative project is presented in six annual reports, four technical reports, and a set of case studies prepared by the Documentation Project. All of these reports are listed in the References. The Site Reports, which offer a retrospective summary of each collaborative's efforts over the grant period, have not been reviewed by

collaborative personnel and thus present the reflections solely of the Documentation Project staff.

II. FIVE-YEAR SUMMARY: 1985-1990

A. Overview

The Cleveland Collaborative for Mathematics Education (C^2ME) was one of the five collaboratives to receive a grant from the Ford Foundation in February, 1985. The grant was awarded to the Cleveland Education Fund (CEF), one of the public education funds established through Ford Foundation funding, which operates solely to support the Cleveland Public Schools. The director of CEF serves as the director of the collaborative and the collaborative's coordinator is employed by the CEF. It also provides the collaborative with office space and clerical support. The CEF, which oversees the funding for the collaborative, received two multi-year grants from the National Science Foundation to support a problem-solving project to be operated through the collaborative. The collaborative experienced a change in directors in 1988 and frequent changes in the coordinator. A very active Advisory Board of over 30 members oversaw the operation of C^2ME. Because of the strength of the Advisory Board, the collaborative experienced little disruption during the 1988 change of directors. The Advisory Board established five standing committees that reported and made recommendations to the Board, including the Advocacy Committee, which served as an advocate for the district's mathematics education program in the larger community, and the Teacher Advisory Board (TAB). The TAB, comprised of 17 teachers, gained increasing influence during the existence of collaborative, counseling the Advisory Board on issues of special interest and concern to mathematics educators. It was renamed the Teachers Advisory Group during the 1989-90 school year.

The C^2ME sponsored a variety of activities including industrial site visits, symposia, dinners, summer institutes, workshops, mathematics clubs and competitions, and a newsletter. It also established the Teachers' Resource Center and sent teachers to professional meetings. The mathematics supervisor worked closely with the collaborative director and coordinator to ensure that collaborative activities reflected the goals of the district's mathematics program. An important part of this interaction were the supervisor's and teachers' presentations to the Advisory Board regarding the reforms being recommended. After their publication, the NCTM *Curriculum and Evaluation Standards* served as guidelines for initiating reform of the mathematics curriculum. In addition to

trying to incorporate more problem-solving activities into the classroom, projects were conducted to increase teachers' use of calculators. The collaborative reached a very high percentage of the over 200 secondary and intermediate schools mathematics teachers in Cleveland; the greatest level of participation, however, was from about 30 percent of the teachers. The collaborative contributed to energizing the district's mathematics program and helped the district take advantage of available opportunities, such as grants from state universities. A number of the mathematics teachers increased their professional activities. Teachers became more knowledgeable about applications of mathematics and incorporated them into their teaching along with a greater number of problem-solving and calculator activities. Teachers assumed responsibility for operating a problem-solving bulletin board over the electronic network. School administrators reported higher mathematics test scores, improved attendance, and a greater number of students taking higher mathematics courses. More students became mathematically active, participating in collaborative-sponsored mathematics clubs and contests. At the end of the five years, mathematics departments were developing model mathematics programs through the Model Mathematics Project, which was initiated by the Advocacy Committee. C^2ME also was working on its problem-solving project and on a UMC Outreach Grant on assessment.

B. Purpose

The earliest recorded purpose for C^2ME was a statement by a senior vice-president of Standard Oil of Ohio who reported that the collaborative was established to provide secondary mathematics teachers greater opportunities and resources and to enhance the quality of mathematics education in the district. Over the five-year period, the stated purpose for the collaborative expanded twice--first in 1986, to facilitate networking among secondary mathematics teachers and mathematicians from business, industry, and higher education, and again in 1988 to advance and reform the secondary school mathematics curriculum in the Cleveland Public Schools. Along with a greater focus on curriculum reform, the target group was expanded to include mathematics teachers from the intermediate schools. A four-year work plan was developed at the end of the 1987-88 school year to direct the collaborative's activities from 1988 through 1992. The overall mission of the collaborative was stated in this plan as follows:

To enhance the professionalism and effectiveness of intermediate and secondary school mathematics teachers by providing opportunities for collegiality, training/professional growth and curriculum development that will enable them to deliver contemporary mathematics education which enhances critical thinking skills and the use of technology and models; and to involve teachers, local business/industry, community members and parents in a shared perspective of contemporary mathematics instruction in the Cleveland Public Schools.

In support of its expressed mission, the collaborative identified four goals: To enhance collegiality among intermediate and secondary mathematics teachers; to enhance the effectiveness and efficiency of mathematics instruction; to develop a contemporary mathematics curriculum that emphasizes critical thinking and the use of technology; and to articulate the mathematics program to all members of the Cleveland community. The evolution of the collaborative's purpose toward district curriculum reform reflects both the greater participation of the mathematics supervisor in the operations of the collaborative and the national recommendations for curriculum reform.

C. Context

Over the five years being documented, Cleveland's population has declined about 17 percent from nearly 600,000 in 1985 to 500,500 in 1990, reflecting a migration of people and factories to the outlying suburban areas. In 1989 alone, Cleveland lost 52 factories. In 1989, the metropolitan area of Cleveland had a population of more than 1.8 million. Student enrollment in Cleveland Public Schools (CPS) has continued to decline since 1972. From 1985 to 1990, student enrollment decreased from 76,000 to 69,500, a 9 percent decline in five years. The ethnic composition of the student body has remained essentially the same with only a small decline in the percentage of white students, accompanied by a small increase in Hispanic students. In 1985, 69 percent of CPS students were black, 26 percent were white, and 5 percent were from other groups. In the 1989-90 school year, 70 percent of the students were black, 23 percent white, 6 percent Hispanic, and a little over 1 percent Asian or American Indian. In 1990, approximately 4 percent of the district's students spoke English as a second language, and more than 60 percent of the students were from families living at or below the poverty level. Approximately 70 percent of the families served by CPS qualified for low-cost or free federally-funded

school lunches. In 1988-89, the annual dropout rate was nearly 18 percent at the high school level and 2 percent at the intermediate level. A new attendance policy was instituted by the district in 1989-90 to automatically give a student absent from any class more than 10 times a failing grade in the course.

The seven-member School Board for the Cleveland Public Schools has generated controversy and turmoil over the five-year reporting period. The Board, for example, bought out the remaining contracts of two superintendents and, among other policy changes, assumed the superintendent's responsibility for adjusting salaries and reassigning principals. From the beginning of the collaborative through June, 1990, the district experienced three changes in superintendents. Dr. Alfred D. Tutela, who served the longest, was the interim superintendent from January, 1984, to September, 1985, and superintendent from August, 1986, through May, 1990, at which time the School Board bought out the remainder of his contract for over $200,000. For the ten-month interim between Dr. Tutela's two appointments, Dr. Ronald A. Boyd served as superintendent until his contract was bought out. Frank J. Huml, who had held a variety of administrative positions for the district, was named acting superintendent after Dr. Tutela's departure. The district's budget over the five-year period ranged from approximately $350 million to nearly $430 million. In 1989-90, 56 percent of the district's revenues were from state sources, 41 percent from local taxes, and 3 percent from other sources.

The district has been working under a court-ordered desegregation plan since the mid-1970s. Because of the district's resistance to desegregation, an Office of School Monitoring and Community Relations was established by the federal court to monitor the integration process. In 1989-90, the district had 127 schools--12 high schools, 20 junior and middle schools, 79 elementary schools, and 16 other schools. In 1986, the district adopted the middle school concept which moved ninth-grade students to high school. As a consequence, some mathematics teachers in the middle grades were transferred to high schools and were assigned to teach courses they had never taught before.

The teaching staff in the district declined 11 percent from 1985 to 1990, from approximately 4,500 teachers to 4,013 teachers, concurrent with the district's implementation of an early retirement program designed to reduce the teaching staff. In 1990, there were 1,273 high school teachers and 665 intermediate teachers. In 1985, 35 percent of the district teachers were from underrepresented groups. This percent

increased over the five years and in 1989-90, 58 percent of the teachers were white, 39 percent were black, 2 percent were Spanish-Hispanic, and less than one percent were from other minority groups. All CPS teachers are fair-share members of the Cleveland Teachers Union, Local No. 279, American Federation of Teachers, AFL-CIO, which is the bargaining agent for contract negotiations. Teachers are employed for 185 school days, including 5 paid inservice days. The salary range for teachers increased dramatically between 1985 and 1990, from $13,600 to $27,721 in 1985, to a range of $21,028 to $44,601 in 1990. The average teacher's salary increased almost 80 percent, from nearly $19,000 in 1985 to $34,931 in 1989-90. Beginning in 1987-88, the school administration and the Cleveland Teachers Union held negotiations regarding the creation of a career ladder program for teachers. Under the program, teachers could earn as much as $4,000 more per year. Planning for the program was shelved in October, 1989, however, because of lack of funding due to budget cuts.

The number of teachers certified to teach mathematics in secondary schools declined from 229 in 1985 to approximately 170 in 1989-90, a 26 percent drop. In 1989-90, all of the 121 high school mathematics teachers and 72 percent of the 67 intermediate mathematics teachers held a secondary certification to teach mathematics. Of the high school mathematics teachers, 79 percent were white, 18 percent were black, and 3 percent were either Asian/Pacific Islander or of Spanish-Hispanic origin. Of the intermediate mathematics teachers, 61 percent were white, 34 percent were black, and 4 percent represented other ethnic groups. A new policy implemented in 1988-89 granted one additional mathematics teacher to each comprehensive high school and intermediate school to either expand the existing curriculum or to make tutoring available with the intent of reducing failures and giving students the opportunity for enrichment. Each school was required to present a plan on how it would use the additional teacher. In the first year of the policy, the district added a total of 120 mathematics, science, and foreign language teachers.

Of the 18,940 students in district high schools in 1988-89, 75 percent were enrolled in mathematics courses. Graduation requirements vary with individual courses of study: vocational, business, and general students are required to take one unit of science and two units of mathematics, and pupils in the college preparation course of study are required to take three units of science and three units of mathematics. The district's mathematics curriculum is the responsibility of a district committee of teachers and the mathematics supervisor.

Over the past six years, the Cleveland Education Fund has provided more than $310,000 through its Small Grants Program for teacher-initiated curriculum projects and supplementary materials. The CEF also sponsored a variety of workshops and lectures related to mathematics, science, and/or writing. Mathematics teachers in Cleveland have the opportunity to participate in a variety of activities offered by the Ohio Council of Teachers of Mathematics and the Greater Cleveland Council of Teachers of Mathematics (GCCTM), as well as in a variety of professional development experiences at near-by universities and colleges including Oberlin College, Lorain County Community College, Baldwin-Wallace College, Case Western Reserve University, and Cleveland State University. The Cleveland Children's Museum also offers programs for teachers. The Cleveland Teacher Internship Program coordinates summer work placement in the private sector for CPS teachers in communications, computer science, laboratory science, mathematics, and technical writing. A number of collaborative teachers have been nominated for and received awards, including the Presidential Award, the Tandy Scholar Award, the Ashland Oil Award for Teaching, the GCCTM Outstanding Educator Award, and the GCCTM's Central District Teacher of the Year.

In 1987-88, the Scholarship-in-Escrow program was initiated to provide an incentive to improve student achievement and to help defray the cost of tuition for college-bound students. Funded by the Greater Cleveland Roundtable, the program awards 7th- through 12th-grade students money in escrow for earning good grades in major subjects--$40 for each A, $20 for each B, and $10 for each C. In 1988-89, a total of 20,000 students earned over $1 million.

D. Management Structure

The management structure for the Cleveland Collaborative for Mathematics Education has been in place from the collaborative's beginning. Central to this structure has been a director who has provided strong administrative leadership and a 30-member Advisory Board that included scientists, engineers, mathematicians, educators (secondary and post-secondary), and professionals in finance, accounting, and applied mathematics. The position of collaborative coordinator has been parttime, with six people having served as coordinator over the five-year period being documented. The coordinator's primary responsibility has been to attend to the administrative details of collaborative activities,

with the exception of the transition periods between the two directors and in the last year of the collaborative, when the coordinator assumed greater responsibility. In 1989-90, the position of the mathematics collaborative coordinator was combined with that of the science collaborative coordinator and filled by one person, Joe Flynn. At this time, the coordinator became more responsible for overseeing the operations of the collaborative. The district mathematics supervisor worked closely with C²ME administrators ensuring that the work of the collaborative was closely tied to his initiatives and those of the district. Throughout the five-year period, the Cleveland Education Fund provided collaborative staff office space and clerical support.

The development of the C²ME can be characterized in two phases that roughly coincide with the tenure of the two directors. The first director, Paula (Fay) Anderson, oversaw the organization and start-up of the collaborative and made the decisions for the collaborative in its formative years. In this period, the collaborative's activities were begun, the Advisory Board and its committees formed, people were invited to participate, and teachers were becoming engaged in collaborative programming. During Ms. Anderson's tenure, the Advisory Board became central to the collaborative, although the Teacher Advisory Board was floundering. The collaborative entered its second phase of development when Ms. Anderson resigned from the CEF, forced by a move away from Cleveland, and Barbara Patterson was hired in February, 1988, as the new director of the Cleveland Education Fund. In this phase, the Problem Solving Infusion Project was funded and began operation, the Teacher Advisory Board became more empowered and was making decisions regarding the allocation of funds for teachers' professional experiences, an Advocacy Committee of the Advisory Board was formed and developed the Model Math Project, and the NCTM *Curriculum and Evaluation Standards* were released, which helped to provide direction and impetus to the collaborative's activities. Ms. Patterson turned collaborative management over to the coordinator and focused on overseeing the general direction of the mathematics collaborative along with the other collaboratives that had been formed by the CEF.

The Advisory Board and its standing committees have played an important role in the development of C²ME. The Board, which met four to six times a year, was guided by the leadership of the business executives who served as chairs. The five standing committees--Teacher Advisory Board (TAB), Program Committee, Public Relations

Committee, Strategic Planning Committee, and Advocacy Committee--reported at each of the Board's meeting. Members of the Advisory Board were given specific tasks to perform in connection with these standing committees, which helped to maintain their interest. When the attendance of business representatives waned, the chair responded by convening a meeting of business and industry representatives to redefine their role. The formation of the Advocacy Committee was an outgrowth of this meeting. To support the role of business representatives as advocates for mathematics reform, guest speakers, teachers, and the mathematics supervisor made presentations on the NCTM *Curriculum and Evaluation Standards* to inform those from business and higher education about recommended reforms. The Advocacy Committee developed the Model Mathematics Project, which provided grants to mathematics departments to develop exemplary programs. Paralleling the development of the Advocacy Committee, the Teacher Advisory Board became more active in counseling the Advisory Board on issues of special interest and concern to mathematics educators and in developing guidelines for collaborative support of teachers who wished to attend professional meetings. Although the Teacher Advisory Board had been established in January, 1986, it did not have a strong focus until the 1989-90 school year, when, renamed as the Teachers Advisory Group, it began to make specific decisions.

At the end of the five years, the governing structure of the collaborative was well established. The business and higher education representatives were interested in the Model Mathematics Project and in the support they could offer schools through the project. The collaborative had a successful history in obtaining grants through the CEF, which gave it financial security. The coordinator was overseeing the collaborative's operation, although the CEF director continued to stay well-informed about the collaborative. Teachers and the mathematics supervisor had strong input into the decisions and activities as the collaborative worked toward mathematics education reform in the district. In these ways, C^2ME had evolved into a smoothly functioning organization dependent on the cooperation of teachers, representatives from business and industry and from higher education, the district mathematics supervisor, and the Cleveland Education Fund.

E. Project Activities

In keeping with the collaborative's mission to enhance the professionalism and effectiveness of teachers by providing opportunities for collegiality, inservice training, enhancement of classroom instruction, curriculum development, and professional growth, C²ME sponsored a variety of programs for secondary and intermediate school mathematics teachers over the five-year period. In addition to these activities, the collaborative encouraged teachers to participate in the numerous professional development opportunities offered by other area organizations.

The collaborative's activities addressed the four themes that had emerged during the documentation process as being dominant in collaborative programming. These themes were: Socialization and Networking, Increased Knowledge of Mathematics Content, Teacher Professionalism, and Teacher Leadership. Socialization activities, especially prominent in the formative years of the collaboratives, were designed primarily to initiate interaction among teachers and between teachers and mathematicians from business and higher education. These generally large-group activities were important to the evolution of the collaboratives since they brought members of the mathematics community together, enabled them to get to know one another, and promoted networking. The second theme, Increased Knowledge of Mathematics Content, encompassed activities designed to provide teachers with mathematics-directed experiences and to increase the knowledge of teachers and others regarding current trends in mathematics and mathematics education. Many of these activities served to activate the agenda of mathematics reform at the collaborative sites. The third theme, Teacher Professionalism, involved activities structured to enhance teachers' conceptions of teaching as a profession. Collaboratives provided opportunities and incentives for teachers to attend professional organization meetings and made mathematics teachers aware of available grants and other opportunities for professional development. Some collaboratives paid teachers' dues for organization membership and arranged for teachers to observe other teachers and reflect on their teaching. The fourth theme, Teacher Leadership, had not been identified at the beginning of the UMC project, but gained greater attention as collaboratives found that teachers lacked the skills needed to organize professional efforts, to plan, and to develop the power within their group to generate systemic change. This theme was advanced by the EDC through the UMC Teacher Leadership Workshops which, beginning in the summer of 1989, were attended by from one to four teachers from each of the collaboratives. However, since this training

was initiated by EDC rather than by the collaboratives, it is not discussed in the reports of the individual collaboratives.

In reflecting on collaborative activities as they related to the four themes, considerable overlap was noted, since most activities served multiple purposes. A single activity may, therefore, be discussed under several headings.

Socialization and Networking

One of the collaborative's original goals was to facilitate sharing, communication, networking, and collegiality among teachers and mathematicians from businesses, industry, and higher education. The collaborative sponsored several programs, including dinner symposia, the Cleveland Mathematics Teachers' Resource Center, and a collaborative newsletter to provide opportunities for teachers to communicate with their peers in the schools, as well as their colleagues in other mathematics-related occupations. The collaborative also played a key role in fostering communication between higher education and the mathematics department of the school district. This resulted in increased opportunities for CPS mathematics students and teachers, including mathematics contests and competitions, a technology grant awarded to Ohio State, and the Mathematics and Technology Human Resources Enrichment (MATHREP) Project and MATHCAMP. In addition, the collaborative's Public Relations Committee worked to promote mathematics education within the larger community.

Dinner Symposia

Over the five-year period, the collaborative sponsored nine dinner symposia. The symposia were designed to provide teachers with an opportunity to share ideas with other teachers and business people, as well as to update their knowledge of current topics in mathematics education. The symposia, which were hosted by area corporations and centers of higher education, were very well-attended by teachers as well as by Advisory Board members, with attendance reaching as high as 125 participants.

The earlier symposia featured tours of the hosting corporations with discussions that focused primarily on applications of mathematics. These symposia promoted networking with representatives from business and industry. As a result of teachers' evaluations of the first two symposia, classroom materials, including packets of application problems, were distributed to teachers at many of the subsequent symposia. Teachers were integrally involved in planning the symposia and sometimes worked with representatives from business or industry to help develop the packets of application problems that were distributed. Symposia programs included tours and discussions at the SOHIO Research Center, Eaton Corporation Manufacturing Services Center, NASA's Lewis Research Center, the microcomputer laboratory and the Center for Automation and Intelligent Systems Research at Case Western Reserve University, National City Bank Operations Center, Nordson Corporation's Amherst facility, and Progressive Corporation. In addition to discussions of the mathematical applications, symposia topics included: an address by Dr. Philip J. Davis, professor of mathematics at Brown University, on "Napoleon's Theroem: The Importance of Geometry"; an address by Dr. Kenneth Cumins of Kent State University, "Helping to Motivate Students in the Study of Mathematics"; an address by Dr. Richard Klein, vice president of corporate research and technology of Nordson Corporation, on the importance of mathematics education in today's business world; and joint presentations by two Cleveland teachers and two employees of the Progressive Corporation, "The Mathematics of Insurance."

The dinner symposia held during the last two years placed a greater emphasis on mathematics content. In January, 1989, for example, the collaborative sponsored a dinner symposium featuring Dr. Henry Pollak, who spoke on "The New Mathematics Standards: Impact on Educators and Employers," emphasizing the need to change the curriculum to better meet the needs of students in preparing them for the future. Dr. Pollak is a consultant and visiting professor at Teachers College of Columbia University who had spent 35 years as a mathematics researcher for Bell Laboratories and Bell Communications Research. The symposium, which was hosted by BP America, with additional support from Case Western Reserve University, National City Bank, and Nordson Corporation, was an outcome of a business/industry brainstorming session. Other symposia during this period included a November 1989 program sponsored by the IBM Corporation designed to provide teachers with an opportunity to update their knowledge of current tools in mathematics education and share ideas with other teachers and business people, at which IBM mathematics software developer Elayne Schulman presented "Math Software for the

Future." In April, 1990, Fenn College of Engineering of Cleveland State University hosted a symposia that featured a presentation by Peter J. Tsivitse, vice president of technology and corporate development at Reliance Electric Company. Dr. Tsivitse spoke on the role of high school mathematics instruction as the foundation for college-level education in the field of engineering.

Cleveland Mathematics Teachers' Resource Center

The Cleveland Mathematics Teachers' Resource Center (MTRC) of C^2ME was established at the Metro Campus of Cuyahoga Community College in October, 1985, as a clearinghouse for information and a meeting place for Cleveland public school teachers. The MTRC, which is staffed by teachers and open from 3:00 to 6:00 p.m. Monday through Thursday, provides a centrally located meeting place for teachers, as well as a monthly calendar of events, a data base on teachers, computer access, an electronic bulletin board system which is used by over 100 schools/individuals, and desktop publishing facilities. The MTRC, which serves as the hub of the district's curriculum development and inservice training, was the site of several collaborative events, including meetings of the Teacher Advisory Board. The MTRC is also a center for the collection, review, and distribution of materials. It provides consultation services and distributes a list of recommended materials to each department chair in order to encourage mathematics departments to obtain supplemental textbooks, supplies, and materials, including calculators, to help teachers implement an activities-based approach to mathematics instruction. On Monday of each week during the school year, 20 problems are posted on the electronic bulletin board--one problem for each day of the week for each of four levels: primary, intermediate, junior high, and senior high. Students enter their responses on the bulletin board, and staff of the Center provided feedback to those responses.

The level of teacher participation in the Center increased dramatically over the first two years and then waned some. Between the Center's opening on October 1, 1985, and December, 1985, 85 teachers availed themselves of its resources. During the same period in 1986, teachers visited the Center 243 times. By the end of June, 1987, the number of visits had increased to 473. During the 1987-88 school year, however, teachers made only 300 visits to the Center.

Collaborative Newsletter

The collaborative's quarterly newsletter was first published in October, 1985, and distributed to teachers and to Advisory Board members. In the spring of 1987, distribution was expanded so that 300 copies were sent to area businesses. The newsletter announces events, programs, and contests; recognizes teachers for personal accomplishments and C²ME participation; and prints articles written by teachers who have attended professional meetings and conferences as well as reprints of articles of interest to mathematics teachers. Until the fall of 1987, the newsletter was edited by Bob Seitz, a high school mathematics teacher and the collaborative's on-site observer for the UMC Documentation Project. Ken Fiore, a mathematics teacher at the Cleveland School of Science, assumed the editorship for the 1987-88 school year. In fall, 1988, Charniece Buford (Holmes), the collaborative coordinator, became responsible for its publication. In April, 1989, the collaborative's Program Committee decided that a Newsletter Committee of four volunteer teachers should review and edit the articles. The Newsletter Committee distributed two issues of the newsletter during the 1989-90 school year--one in the fall and one in the winter. In addition to the newsletter, in March, 1990, the Cleveland Education Fund initiated publication of the *Collaborative Update*. This monthly bulletin lists opportunities for professional development that are available in the Cleveland area, especially for teachers of English, science and mathematics.

Mathematics Clubs and Competitions

In 1986, the Aetna Foundation awarded a grant to C²ME to fund mathematics clubs in Cleveland intermediate schools and high schools. Between 1986 and 1990, Aetna contributed over $68,000 to C²ME, including $18,000 in the 1989-90 school year. The program was very effective. Prior to the award, there were only ten mathematics clubs in the schools; during 1988-89, 31 of the district's 42 secondary schools operated clubs. By the 1989-90 school year, 26 mathematics clubs in 25 intermediate and high schools participated in the mathematics clubs program. Funds of up to $400 were granted to each of the collaborative's mathematics departments to finance the clubs each year. The money was used for mathematics manipulatives, field trips to area businesses, software, and mathematics competitions.

Grants to schools were contingent upon a commitment to participate in at least three mathematics competitions during the school year. In 1985, the Cleveland Public Schools had only two teams participating in the MATHCOUNTS competition; in 1986, with collaborative support, the number of participating teams increased to 24. In 1986, the Greater Cleveland Council of Teachers of Mathematics (GCCTM) mathematics contest was held in a Cleveland Public School building, the first time that the district opened a school building for the contest. Twenty-nine teams entered from the CPS, representing the largest number of teams ever entered by the Cleveland Schools.

Other contests in which Cleveland students participated included those sponsored by the Ohio Mathematics League; the Mathematics Triathalon, sponsored by C^2ME in conjunction with Cleveland State; and the C^2ME/John Carroll Mathematics Competition. The latter contest provided an opportunity for collaborative teachers to work with representatives from higher education in a university setting. The competition, which is underwritten by Aetna Life and Casualty, has grown since it was first held in 1987-88. It began as an algebra competition, but geometry was added in 1988, and advanced mathematics in 1989. Approximately 500 students, forming 102 teams representing 20 CPS intermediate and high schools, participated in the 1990 competition--more than three times the number who participated in the 1987-88 contest. In 1990, for the first time, the contest was held during school hours to demonstrate that participation in a mathematics competition is a viable reason for students to miss scheduled classes.

MATHREP and MATHCAMP

In April, 1987, the Ohio Board of Regents granted $41,000 jointly to the Cleveland collaborative, Baldwin-Wallace College, and the Cleveland Public Schools to fund the Mathematics and Technology Human Resources Enrichment Project, which addressed the under-preparedness of mathematics teachers in the intermediate schools. The funds were for stipends, manipulatives, and books. In Phase I of the project, a three-week MATHREP workshop was held in the summer of 1987 which was attended by 23 participants, including 15 Cleveland Public School Teachers. In Phase II, between September, 1987, and January, 1988, nine Saturday meetings were held. Each teacher participating created a project to be used as one week's lesson plans in his/her class. Phase III was a one-week Summer MATHCAMP for the 60 middle school students who scored

the highest on a competitive exam and were nominated by Phase II teachers. The camp was held in August, 1993, on the campus of Baldwin-Wallace College.

Community Outreach/Public Relations

To promote networking and collegiality and to strengthen the link that existed between C²ME and the Greater Cleveland Council of Teachers of Mathematics (GCCTM), the collaborative sponsored a display area at the 1986 fall meeting of GCCTM. The exhibit, which was staffed by secondary school mathematics teachers from the Cleveland Public Schools, disseminated information and materials about the collaborative. The collaborative and Oberlin College also jointly sponsored special activities for Cleveland Public School teachers as part of Oberlin College's Mayfair Festival in May, 1987.

The collaborative's Public Relations Committee, one of five standing subcommittees that operates under the jurisdiction of the collaborative's Advisory Board, worked to promote the activities of the collaborative as well as to improve the image of mathematics education within the community. During 1989-90, the committee orchestrated a television public service program and the publication of a story about a middle school mathematics teacher in a local magazine. During Mathematics Awareness Week in 1990, C²ME and the Department of Mathematics and Computer Science at John Carroll University co-sponsored a guest lecture by Dr. Uri Treisman that was attended by 60 people, including 20 C²ME participants. Dr. Treisman is the 1987 recipient of the Charles A. Dana Award for Pioneering Achievement in Higher Education and is currently working with the Dana Foundation to start the Dana Center for Innovation in Mathematics Education. In his presentation, "Teaching A Changing Population in Turbulent Times," Dr. Treisman discussed his findings regarding fundamental differences in methods of studying for several minority groups and their successes in mathematics.

Increased Knowledge of Mathematics Content

The collaborative directed much of its programming toward increasing teachers' understanding of mathematics and its current applications. Many of the programs focused on problem solving, consumer mathematics, and the use of calculators, with the

collaborative playing an active role in promoting the use of calculators in the district's mathematics curriculum. Programs offered over the five-year period included seminars in advanced technologies, workshops, and participation in the Problem-Solving Infusion Project and in the Cleveland Teachers' Internship Program. The dinner symposia, discussed under the previous heading, also provided opportunities for teachers to update their knowledge of current topics in mathematics education. Many of these programs were conducted collaboratively with an institution of higher education, a business, or industry.

Seminars in Advanced Technologies at Lorain County Community College

In spring of 1985, 1986, and 1987, Lorain County Community College's High Technology Center offered week-long courses that focused on mathematics in high technology industries. The five-day programs were designed to broaden the experience of junior and senior high school mathematics teachers through participation in a series of workshops on advanced technologies. A total of 33 collaborative teachers participated in the four seminar series, with participants receiving continuing education credits, tuition, mileage, and lunch allowances, as well as a $100 stipend. At the workshops, teachers were instructed in the basic concepts of new technologies and made aware of the integral part that mathematics plays in each. In general, the series consists of introductory sessions on the IBM PC, followed by a series of four four-hour advanced technology workshops in the areas of computer-aided graphics and design, computer numerical control of machinery, robotics, and statistical control of processes and quality. Teachers spent the afternoons in small groups working on ways to integrate the a iced technologies into the mathematics curriculum and also participated in hands-on experiences with the advanced technologies.

Oberlin Problem-Solving Workshops and Seminars

The collaborative worked cooperatively with Oberlin College to offer teachers summer workshops on problem solving. In June, 1986, six secondary school mathematics teachers received collaborative funding to attend a problem-solving workshop at Oberlin College designed to sharpen teachers' skills, to help them build a problem-solving library and to guide them in preparing a plan for classroom implementation. The workshop was

led by Dr. Rudd Crawford, who is a mathematics teacher at Oberlin High School, the director of the SATELLA Project in problem solving, and an instructor at Oberlin College.

In addition to the summer workshop, Oberlin College sponsored six weekend seminars on problem solving during the 1986-87 school year. Each session included a Friday dinner meeting and a Saturday breakfast meeting with the full program lasting into the afternoon on Saturday. Fifteen teachers were eligible to participate in each seminar. Places not filled by CSP teachers were filled by teachers from neighboring districts; the opportunity provided for the teachers to mix with colleagues from outside the local system added an important dimension to the activity. By the end of 1986, one quarter of the collaborative's target population had taken part in the summer problem-solving workshop or weekend seminars. Teachers who were selected to participate in the sessions wrote problems that were added to the set of problems that had been distributed at a district-sponsored workshop on problem-solving held in August, 1986. As a result of the enthusiasm generated by these sessions, a Problem Solving Standing Committee comprised of Cleveland teachers was formed to collect data about the use of the problems and to develop and distribute additional problems.

Collaborative Workshops

The collaborative sponsored a variety of workshops over the five-year period, many of which were conducted by collaborative teachers.

Calculator Workshop. In 1986, the collaborative initiated an inservice workshop for intermediate mathematics teachers to ensure that they were comfortable working with calculators and to integrate them into the curriculum; it was the first systematic calculator curriculum to be introduced in the Cleveland Public Schools. Fifty-one intermediate teachers attended. The plan for incorporating calculators into the district's curriculum illustrates how the collaborative served as a catalyst: the Cleveland Education Fund contributed $5,000 to the cost of calculator materials; the Cleveland Public Schools paid teachers for their attendance at the inservice training sessions; the State of Ohio paid for three national trainers, a facility, and refreshments; and the collaborative assisted in developing, disseminating, and implementing new units and activities that were created as a result of the inservice training.

1988-89 Workshop Series. The collaborative sponsored four workshops during the 1988-89 school year. The first workshop, held in August, 1988, focused on topics in fourth-year high school mathematics and provided instruction in software developed by the North Carolina School of Science and Mathematics (NCSSM). The workshop, which was attended by 10 collaborative teachers, was presented by two of the three teachers who had participated in a program on fourth-year college preparatory mathematics at NCSSM during the summer of 1987. The second workshop, held in September, 1988, was designed to provide teachers with hands-on experience with the computerized gradebook. Participation was limited to the first 20 teachers to apply. In November, 1988, the collaborative sponsored a workshop featuring David Johnson, chairman of the Mathematics Department at Nicolet High School in suburban Milwaukee and author of the books, *Every Minute Counts: Making Sense of Your Math Class Work* (1982) and *Making Minutes Count Even More* (1986). Mr. Johnson provided tips on the art of questioning and on efficient homework correction, and a practical notebook system, as well as suggestions for daily organizational techniques. Approximately 60 people attended, including eight Advisory Board members. In February, 1989, the collaborative sponsored a workshop on the graphing calculator that was conducted by five collaborative teachers. The workshop was attended by 26 mathematics teachers and 3 science teachers, each of whom received a graphing calculator.

"For Teachers By Teachers" Workshop. To launch the 1989-90 school year, in August, 1989, the collaborative sponsored a workshop, "For Teachers By Teachers." Participants had the opportunity to preregister for two of six potential sessions. At the workshop, four of the six sessions were actually presented--all by Cleveland teachers: Computer Graphing and the Electronic Chalkboard, NSF Problem-Solving, the Computer Bulletin Board, and Geometry Fair Ideas. In addition to attending two sessions, teachers had the opportunity to view displays that included materials about the Cleveland Education Fund small grants Program, applications for professional conferences, and materials by Creative Publications. The workshop, which was attended by approximately 80 teachers, concluded with a luncheon address on the parallel issues of equity and alternative assessment methods by Professor Genevieve Knight of Coppin State College in Baltimore, Maryland.

Problem-Solving Infusion Project

In November, 1988, the Cleveland Education Fund received a four-year $400,000 grant from the National Science Foundation to develop a program to infuse problem solving into the 7th- and 8th-grade mathematics curriculum. Eleven teachers volunteered to consult on the project during the year and to meet with Dr. Crawford of Oberlin College twice a month to discuss problems and their students' reactions to them. The problem worksheets that were developed were collected in a notebook that was made available to other teachers.

Industry Internships

The Cleveland Teachers' Internship Program (CTIP) was established in 1980 to provide teachers with hands-on experience involving the mathematics used daily in business and industry. The program organizes summer work placements for teachers in area businesses or industrial laboratories for which teachers receive a stipend. In addition to working at the corporation, teachers attend approximately six afternoon seminars over the course of the summer and prepare a project for their own classrooms. In the summer of 1985, C²ME coordinated 11 placements in industry and in a parallel effort, identified one internship at Cleveland State University. In summer of 1986, seven teachers, many of whom had participated in the 1985 program, had internships. Seven mathematics teachers participated in the internship program during the summer of 1987 and eight intermediate and secondary mathematics teachers in the summer of 1988. Prior to C²ME, only one Cleveland Public School Mathematics teacher had been placed through CTIP.

Teacher Professionalism

A primary focus of the Cleveland Mathematics Collaborative for Mathematics Education was to enhance the professional growth of teachers. The collaborative has provided mathematics teachers with opportunities and experiences not previously available to them to heighten their sense of professionalism. The collaborative awarded travel grants to enable teachers to participate in meetings of professional organizations, many for the first time; assisted teachers in applying for grants under the Small Grants Program

available through the Cleveland Education Fund; arranged for Teacher Scholarships from John Carroll University; and, through events such as the Retirement Dinners, helped teachers to receive recognition for their service. The collaborative has encouraged teachers to assume an important role in the development of the district's mathematics curriculum, assuming a new level of responsibility. Teachers have also increased their participation in professional organizations, assuming leadership roles in the Greater Cleveland Council of Teachers of Mathematics and making presentations at the annual conferences of the Ohio Council of Teachers of Mathematics. The Cleveland Mathematics Teachers' Resource Center, which provides a meeting place teachers can call their own, has also contributed to the strong professional identity among Cleveland mathematics teachers.

The collaborative served as a catalyst, promoting teachers' participation in important professional activities, including curriculum development and teacher inservice training. As a result, teachers are receiving recognition and assuming responsibilities they had not experienced previously. When, for example, the Teacher Advisory Board suggested that a consumer mathematics course be developed, the school district organized a committee of five teachers to work over the summer to develop the curriculum. Teachers have been involved in creating curricular materials, in many cases drawing on input from university and industrial mathematics. Eleven middle school teachers, for example, are working as consultants on the Problem-Solving Infusion Project, helping to develop problems that require visual thinking, and processing information from visual to verbal and back again. The problems that they are developing will be made available to other teachers through the Cleveland Mathematics Teachers' Resource Center. Between January and March, 1989, seven mathematics teachers met regularly with nine science teachers to develop curriculum as part of the AIMS (Activities that Integrate Mathematics and Science) program. The program is jointly sponsored by the C^2ME and the Cleveland Science Collaborative. Following the 1986 Oberlin Problem-Solving Workshop, the collaborative paid the six CPS teachers who participated to spend two weeks organizing and further developing the problem-solving materials, as well as planning two one-day workshops on problem solving for CPS mathematics teachers. The workshops, which were held in August, 1986, were sponsored by the Cleveland Public Schools and attended by a total of 137 teachers of Grades 7-12. In 1986, the CPS mathematics supervisor formed a committee of 23 teachers to review and revise the pupil performance objectives and to work on developing midterm examinations to be administered in each school. Three

collaborative teachers, after participating in a summer training session at th. .orth Carolina School of Science and Mathematics, acquired a Small Grant from the Cleveland Education Fund to enable them to pilot-test the materials developed at the NCSSM for fourth-year college preparatory mathematics. These teachers conducted a workshop for Cleveland Public School teachers during summer of 1988.

Travel Grants

C²ME has committed itself to increasing the attendance of Cleveland Public School secondary mathematics teachers at professional meetings, since their traditionally low attendance was considered an impediment to their professional development. As part of its efforts to promote teacher participation in professional meetings, the collaborative awarded funds to support teachers' attendance at a variety of regional and national conferences and at meetings of professional organizations. The collaborative, which awarded 128 travel grants during the five-year period, had difficulty in getting the district to release teachers to participate in professional meetings. Most often, teachers had to take personal leave with pay, and substitute teachers were provided through the CPS mathematics supervisor's general fund. Among the events that teachers received collaborative funding to attend were the 1989 NCTM Northeastern Regional Conference in Philadelphia; the 1987, 1988, 1989, and 1990 Annual Meetings of the Ohio Council of Teachers of Mathematics Conference; the 1988, 1989, 1990 Annual Meetings of the National Council of Teachers of Mathematics (NCTM); the Region I Workshop, Making Mathematics Work for Minorities, in Chicago in 1989, which focused on reversing long-standing patterns of underachievement and underrepresentation of women and minorities in the mathematical sciences; the 1986 and 1987 Conferences on Computers in Secondary School Mathematics at Phillips Exeter Academy; and a Conference on Educational Collaboratives in 1986.

In addition to financing teachers' travel, the collaborative also arranged funding for district mathematics supervisor Bill Bauer to attend the annual meeting of the National Conference of Supervisors of Mathematics in 1987 and located funds that enabled him and Rudd Crawford to attend the Harvard Regional Mathematics Network Information session. The information they received was helpful in writing a proposal to NSF for money to finance the Problem Solving Infusion Project.

Small Grants Program

The collaborative has made a concerted effort to encourage teachers to apply for grants from the Small Grants Program of the Cleveland Education Fund. The collaborative held two information meetings for mathematics teachers in 1986 to explain the philosophy of the program and distributed a booklet about the program to all mathematics teachers. The collaborative also provided consultation and assistance to mathematics teachers who were interested in applying for grants.

Between the 1984-85 and 1989-90 school years, the Cleveland Education Fund awarded a total of 79 Small Grants for mathematics-related projects. Prior to C²ME's involvement, only one of the grants had been received by a Cleveland Public School mathematic's teacher. Eight grants were awarded during 1984-85 and seven during 1985-86 for a total of $6,170. The maximum amount for a single grant is $500. Ten grants, totaling $4,602, were awarded during 1986-87. In 1987-88, 22 grants were awarded to mathematics-related projects on the intermediate and high school levels and 23 in 1988-89. The grants awarded between 1987-90 averaged $430. Of the 19 grants awarded for mathematics projects in 1989-90, 11 were at the elementary level, 4 at the intermediate level, and 4 at the high school level. Projects included Evaluation and Measurement, Motivation with Manipulatives, Math Motivators and Manipulatives, The IBM *Mathematics Exploration Toolkit*, Informal Geometry, Hands-On Magical Math, and a project by an intermediate school mathematics teacher to implement a Math Lab.

Recipient of Small Grants Awards during 1989-90 were honored at the 1990 annual dinner of the Cleveland Education Fund.

Teacher Scholarships

One of the goals of the collaborative was to provide opportunities for teachers to pursue their individual study of mathematics. As part of its commitment to the C²ME, the Department of Mathematics at John Carroll University offered scholarships to mathematics teachers in the Cleveland Public School. Scholarships cover tuition for university mathematics courses, ranging from introductory calculus and statistics to

graduate courses in the department's Master of Arts and Master of Science programs. One award was made for the summer of 1985, two for 1986, one for the summer of 1987, two for the summer of 1989, and one for the summer of 1990.

A Cleveland Public School's mathematics teacher also received a scholarship from the Martha Holden Jennings Foundation to attend a one-week workshop on problem solving led by Dr. Johnny Hill of Miami University during the summer of 1986.

End-of-Year Retirement Dinners

The collaborative initiated annual end-of-year dinners to honor retiring mathematics teachers at the end of the 1986-87 school year. The dinner held in June, 1987, to honor the 11 mathematics teachers retiring from the Cleveland Public Schools was the first in people's memory to honor anyone for service to the school system. The dinner was attended by 35 teachers. The second dinner, held in June 1988, was attended by more than 90 teachers. At the dinner, Frank Demana and Alan Osborne of Ohio State University, along with several teachers, presented an overview of the calculator project being implemented in the intermediate schools. The third dinner, held in June, 1989, was attended by more than 75 teachers and C²ME staff. At the dinner, Bill Bauer presented a slide show, recounted the teaching history of the retirees, and presented each of them with a gift.

Teacher Leadership

The collaborative placed a high priority on teachers' involvement very early in its development so that over the years a strong core of teachers has emerged. Through their participation on the Advisory Board and its standing committees, teachers have assumed leadership roles. In addition, the collaborative has been successful in encouraging teachers to accept collaborative responsibilities that are typically assigned to staff in other collaboratives, such as editing the collaborative's newsletter. Teachers also took the initiative in planning a professional day for a citywide gathering of mathematics teachers. The Teacher Advisory Group had hoped that the school district would plan a district-wide inservice in fall, 1989, but when it appeared that this would not occur, teachers organized

the workshop. Seven teachers met with the CPS Mathematics Supervisor in the summer of 1989 to plan the program, which was appropriately named, "For Teachers By Teachers." Not only did the teachers plan the workshop, but the four small-group presentations were presented by collaborative teachers.

Teachers also demonstrated leadership within their mathematics departments. During the 1989-90 school year, the collaborative sponsored a district-wide competition, The Model Mathematics Project, inviting high schools to submit proposals for grants of $50,000 to $75,000 to develop a program to implement the NCTM *Curriculum and Evaluation Standards for School Mathematics*. The proposals required a four-year commitment from the high school. Two schools were to be selected to receive four-year funding, beginning in the 1990-91 school year. The staff at the Cleveland Education Fund was available to provide guidance, focus, and support to the schools as they prepared their proposals. The two winning schools, John Adams and Glenville High Schools, were publicly recognized at the May 1990 meeting of the C²ME Advisory Board. The focus of the Glenville proposal was on developing its mathematics teachers into a team of specialists by promoting experimentation with alternative presentation styles, tools, and evaluation strategies. The teachers at John Adams will use the grant to continue to rewrite the mathematics program and to upgrade courses. They are experimenting with calculators, computer demonstrations, manipulatives and cooperative learning, and alternative methods of assessment. To secure financial support for the three other finalist schools, the Cleveland Education Fund submitted a proposal to the NSF. In further support of the Model Mathematics Project, the collaborative received $10,000 in funding through a UMC Outreach Action Grant. The funds will be used to assist teachers in the two schools in their efforts to implement new assessment strategies.

F. Reflections

The Cleveland Collaborative for Mathematics Education has continued to enhance the professional lives of intermediate and secondary schools mathematics teachers and to engage the larger community, including those from business, industry, and higher education, in improving mathematics education in the schools. Problem solving has been the major theme throughout the existence of the collaborative. Through the Cleveland

Education Fund, the collaborative has marshalled the support of teachers, the CPS mathematics supervisor, business executives, professors, and other area resources to impact significantly on the district's mathematics program.

A major success of the C²ME has been its ability to attract new resources to the mathematics program. Teachers who at the beginning were very skeptical of the collaborative have become energized and are attending professional meetings for the first time, trying new forms of teaching, speaking out more about mathematics education, and becoming more knowledgeable about the use of technology. A very high percentage, around 80 percent of the mathematics teachers in the intermediate and secondary schools, have participated in at least one collaborative activity, while a core of 20 to 30 teachers have actively served on the Teacher Advisory Board and regularly attended collaborative activities. The collaborative has been successful in furthering the recommendations of the NCTM *Curriculum and Evaluation Standards* in the Cleveland Public Schools and in educating others in the community about the recommendations in the document. A mathematics professor from an area university wrote an article in support of what is envisioned in the *Standards*. The collaborative has also reached out to students. Funding was obtained through the collaborative for the development of student mathematics clubs in the high schools. The collaborative has since 1987 also helped to sponsor a mathematics contest, first in algebra and then, in an expanded effort, geometry and advanced mathematics. In these ways, as well as through workshops and symposia, C²ME has been able to focus resources in a variety of ways that have benefitted the district's mathematics program. As a result, a new climate for change in mathematics education has been created in which teachers, business representatives, and academians are all working toward reform.

The collaborative has experienced struggles, but very few failures. However, it has had difficulty actively involving a larger proportion of the mathematics teachers in the district. Even though, as noted, a large percentage of teachers have participated in at least a few collaborative activities, the major leadership and involvement have come from less than a fourth of the teachers. Collaborative participation has tended to be concentrated in particular schools in which nearly all members of the mathematics department have become very active. Another area for growth is the development of interaction between the mathematics and the science collaboratives. Both are administered through the CEF and, in 1989-90, shared the same coordinator. However, the mathematics collaborative is

directed more toward the professional development of teachers while the science collaborative's priority is on increasing teachers' knowledge of science and of curriculum changes. The potential exists for the two groups to undertake joint projects that could benefit both. Some of the associates from higher education have been surprised that this had not yet occurred. While there also has been some missed opportunities, what the collaborative has accomplished has significantly benefited the district, the teachers, and the community.

In looking back, there is very little in the development of C²ME that should have been changed. The first director controlled the decision-making process and set the course for the collaborative. As a result, in the early stages teachers did not have much say about what the collaborative did. Under this director, however, a very solid organization was formed. Whereas other collaboratives tried to include teachers in decision making from the beginning, the experience in Cleveland suggests that this is not always necessary in developing a strong, active collaborative. C²ME, however, now needs to face the challenge of expanding the number of teachers willing to be active. Well over half of the mathematics teachers attend one or two collaborative activities but do not assume any ownership or responsibility for the collaborative's on-going programs.

Collaboration Outcomes

C²ME has successfully engaged members of the corporate world and those from higher education in collaboration with teachers to advance mathematics education in the Cleveland schools. A major form of collaboration effort has been in collaborative governance. Other forms include site visits, mathematics contests, presentations, institutes, and projects such as the NSF Problem-Solving Infusion Project. One important by-product of this collaboration is the formation of a group of business and higher education representatives who feel strongly about working with and supporting teachers. The Advocacy Committee is one such example. The professors and teachers working on the problem-solving project is another. The evolution of this form of collaboration can, in part, be attributed to the leadership and initiative exercised by the chair of the Advisory Board, the directors of the CEF, the mathematics supervisor, and a few from higher education. Other contributing factors are the focus provided as a result of the consistent emphasis on problem solving and the leadership of a group of teachers who have been

willing to serve on committees and develop activities for other teachers. Participants from business and higher education have been impressed by the commitment of these teachers and consequently are willing to make greater time commitments of their own.

The Model Mathematics Project has generated opportunities for collaboration. Funds were raised and the parameters of the program were defined by CEF and the Advocacy Committee. When the team of collaborative members not affiliated with the school system visited the schools to hear presentations on the proposals, some were in fact visiting schools for the first time. In very few collaboratives have persons from business and higher education come to the schools to hear presentations by teachers. Having those from the other sectors experience the conditions of classroom teaching and what the teachers face each day helps to break down the barriers that exist among the different groups.

The concept of advocacy is important in Cleveland and is seen as a critical contribution of the collaborative. Cleveland is described as "a political town." Advocacy represents a more advanced stage of collaboration than simply providing resources or attending meetings because it requires an understanding of the educational system and the direction that those in the program want it to go. Advocacy is practiced as a pro-active means of effecting change.

Representatives from higher education have contributed to the collaborative by providing expertise and support. Local campuses have conducted summer institutes, John Carroll University has conducted mathematics contests, and professors are working with teachers on the Problem-Solving Infusion Project. The involvement of university personnel has been motivated by a desire to be helpful, but some academicians have benefitted by using their association with the collaborative as one supporting factor when writing proposals for grants. Thus, collaboration has been beneficial to both teachers and those in higher education.

Another significant impact of C^2ME has been the increased collaboration and interaction among teachers within individual school mathematics departments, which has helped to develop a different environment for teaching and is having some impact on students. Although the Model Mathematics Project contributed to this new environment, greater collegiality among mathematics teachers was developing even before this program

was initiated. As one middle school teacher noted, "There is a difference in the school atmosphere since before the collaborative. You could measure the improvement because of the collegiality factor. There is a definite increase in the number of kids taking higher-level courses and a decrease in the number of kids who are failing. . . . Teachers feel good about themselves . . . a sense of fellowship."

Intermediate and secondary mathematics teachers feel that the collaborative has enhanced their professional lives, especially through the support system for mathematics teachers developed by the collaborative. A greater number of teachers have assumed leadership roles and become active in decision making within their schools, within the district, and in professional organizations. Teachers also have become more active professionally by attending meetings and participating in other professional development experiences. The work of the collaborative has sometimes been carried out so smoothly in conjunction with that of the mathematics supervisor that the two became indistinguishable. In one sense, this is an indication of the extent to which the collaborative has become embedded within the district.

The collaborative has provided teachers an extensive support system. The various projects that have been undertaken encouraged mathematics teachers to work together. For example, as a result of the initiative of the mathematics supervisor, middle school teachers have been working on a calculator project that is funded partially by the collaborative. Teachers have also gotten to know each other better through attending conferences and symposia and working on committees.

Some of the collaboration can be attributed to the work of individuals who have recruited others and encouraged them to become actively involved. A teacher who had only occasionally attended collaborative programs, for example, noticed that teachers who were active in the collaborative were taking advantage of some of its resources, bringing materials back from its events, and using them in their classes. His interest was heightened by overhearing talk in the teachers' lounge regarding the new ideas circulating. This teacher had felt that he was an outsider because, like a number of mathematics teachers in Cleveland, he was not a mathematics major. The collaborative teachers, however, began sharing with him some of the latest ideas in mathematics education and demonstrated the use of the computer. He contrasted this environment with what it was like before the collaborative,". . . . We were free to try things but we didn't know the

possibilities . . . [now] we are encouraged to try things and we feel comfortable doing them . . ." Some of the peer pressure had its effect on him," . . . when you see four or five guys doing things there isn't any reason not to try." One of the outcomes of the collaborative for this teacher was that for the first time in 21 years of teaching, he went to the Ohio Council of Teachers of Mathematics meeting. For him, the collaborative has greatly reduced his isolation, "I enjoy coming into work after 21 years because of the influence of the collaborative. You can feel alone in that classroom [but] you are not alone. You have backup all over the place. . . . Help is always there. Nothing that you used to dread can go wrong now."

The Mathematics Teachers' Resource Center is another factor in the support that mathematics teachers feel they now have. The teacher-operated Center provides a meeting place for mathematics teachers and those who work there offer assistance as needed. The Center is stocked with materials, books, and software. Teachers can call the resource teachers with questions or inquiries. The resource teachers will then respond, sometimes researching the best solution to individual teacher needs. The problem-solving bulletin board provides a means of accessing all schools through electronic mail. The teachers who work in the Center donate a significant amount of time and effort developing the problems, giving feedback on responses to the problems, and maintaining a data base on those who use the bulletin board.

Teachers in the collaborative have begun to assume leadership roles. The two resource teachers at the Center are one example of this. Others include the teachers who serve on the Teacher Advisory Group, the Advisory Board, and the Program Committee. An increase in leadership activity has also been apparent within some mathematics departments, as demonstrated by the two departments who received grants through the Model Mathematics Project. Even though demonstrated leadership has remained confined to less than a fourth of the teachers, other teachers have become more involved in decision making than was the case prior to the creation of the collaborative.

The close collaboration has provided those from the business sector with insights into the teaching profession and has influenced their perceptions of teachers. One engineer, when asked to compare a teacher with someone in his company, expressed his sense that a teacher is most like a manager of a small research and development group. "[The manager] has a lot of demands to be selling, influencing, and converting people. . . .

He sets direction and constantly coaches his people to keep them on target . . . convincing them this is a great idea. He has a vision and is working on it." Clearly this person has a high regard for teachers and what they do. The collaborative has helped him to perceive teachers as professionals. He admits that his involvement has been rewarding to him, "I've enjoyed doing this and getting an appreciation for the kind of things [teachers] have to deal with . . . parents . . . kids. . . . [It has been] pretty rewarding to me to get to know them."

Mathematics Focus Outcomes

The C²ME has had a significant impact on mathematics education in at least some Cleveland schools. Principals at two schools reported improvements in student test scores which they attribute, at least in part, to teacher involvement with the mathematics collaborative. One principal's goal is "to get inside the classrooms and improve the instruction and make kids active participants in their own education." He reported that a greater number of students were taking higher level mathematics courses and that fewer students were failing mathematics classes than previously. He describes the collaborative as a ". . . program that makes a teacher feel like a professional, gives her/him an opportunity to interact with other professionals. . . . to bring quality ideas back to the classroom is going to make that teacher a better teacher and the quality of education better." An active collaborative teacher noted some changes she had made because of the collaborative and how these changes had affected her students, "I've gotten the students involved in ways I would have never guessed. Ideas I've picked up from the collaborative . . . manipulatives, problem-solving units on cubes, and cube trays. Kids said, 'This is math?' When you do something that is not numbers, the lost kids get interested." The director of the CEF also noted that teaching has improved. She reports, ". . . some schools now have two-period algebra, more students are turning in homework, there is better attendance in classes, more people are taking higher-level mathematics classes, and the teachers are enthusiastic."

The major mathematics focus of the collaborative was problem solving. This is reflected in such innovations as the problem-solving bulletin board, the problem-solving projects, the work with calculators, and the teacher institutes. With the publication of the

NCTM *Curriculum and Evaluation Standards*, in which problem solving is one of five primary goals, the collaborative was in position to take full advantage of this impetus. Members of the Advisory Board were instructed on the content of the *Standards* and their significance at both the national level and in local mathematics education efforts. A chair of the mathematics department at a local university and member of the Advisory Board wrote a one-page letter in support of the *Standards* that was distributed by the collaborative. One of the business representatives commented that the *Standards* made sense. It is out of these beliefs that the work of the Advocacy Committee came to focus on the *Standards*. There is little doubt that without the collaborative, the *Standards* would not have received the attention they have in Cleveland.

Other ways that the collaborative has influenced the mathematics education climate in Cleveland include conducting mathematics contests, supporting the development of mathematics clubs, and supporting the Mathematics Teachers' Resource Center. These forces, along with the presence of a very active mathematics supervisor, have resulted in an energized group of teachers and the implementation of a number of forward-looking programs.

Conclusions

The Cleveland Collaborative for Mathematics Education has successfully brought together teachers, representatives from business and industry, academicians, and others to create a collaborative. A very active program has developed that reflects the available resources, the needs of the district, and the efforts of the people who were involved. Overall, the collaborative seems well positioned to address the important issues facing it and to further mathematics education in the area. The active commitment of those from the business and higher education sectors is a very strong component of the C^2ME. This, along with an active core of teachers, a highly respected mathematics supervisor, and strong administrative support from the CEF, gives the collaborative a solid foundation from which to significantly impact mathematics education in Cleveland.

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