MATHEMATICS AND SCIENCE LITERACY – BRIDGES TO CAREERS

Introduction

Business, industry, and government studies portray a compelling picture of the landscape of the 21st century workplace in the United States. More than ever, jobs will require a solid foundation of mathematics and science, the ability to apply important principles from these disciplines, and the ability to use technology to solve problems involving mathematics and science. Currently the United States is experiencing a critical shortage of engineers, to the extent that immigration policies are constantly changed to provide additional engineers to staff universities and technical industries.

To quote U.S. Secretary of Education, Richard W. Riley (1998), "Demand for skills in mathematics, science, and technology are continually increasing. To be successful in college and the workplace, students should take at least three years of rigorous high school math. We now believe that by the end of the eighth grade, students should have mastered the fundamentals of algebra and geometry to be ready for high school and on track for college and the workforce."

The workforce that will be needed for these jobs must have a threshold level of mathematics and science literacy beyond that which was necessary in the mid-twentieth century. These workers must be able to solve complex problems using mathematics and science principles and processes to successfully compete in a rapidly-paced international marketplace.

Recently, Assistant Secretary of Education, Patricia McNeil, asked an 11th grader who was interning in a job what he thought was the minimum level of mathematics necessary to perform the job of auto mechanic. The student-intern responded without hesitation, "Algebra 2."

Locally, the Greater Miami Chamber of Commerce's Community Long-Range Planning Committee projected a shortfall of at least 120,000 jobs by the year 2005, based primarily on infrastructure weaknesses. The One Community One Goal® initiative was developed to produce jobs through supporting the growth of targeted industries, such as, biomedical, information technology, and international commerce. The lack of a skilled and technically-qualified workforce has become the focal point for driving substantive, systemic changes in educational programs, content and experiences. Recognition of the practical "disconnect" between the school curriculum, related educational experiences, and the actual needs of a rapid-paced, international economy has reinforced the urgency for changes in the mathematics and science programs and for changes in the delivery system itself.

The preparation of a competent workforce for the Miami-Dade community requires essential and critical goals for student knowledge and skills. For mathematics these

goals are that every student who graduates from Miami-Dade County Public Schools will have completed a minimum of Algebra I, Geometry and Algebra II, and will be able to utilize mathematics principles to solve problems in real-life contexts. For science, these goals are that every student who graduates from Miami-Dade County Public Schools will have completed a minimum of Earth/Space Science, Biology, and Chemistry (or Physical Science), and will be able to utilize science principles to solve problems in real-life contexts. Miami-Dade County Public Schools' graduates will possess the mathematics and science literacy necessary for success in post-secondary education and as employees in the workplace. These graduates will be able to compete in the global marketplace for the jobs of the future.

The ability to apply the principles and concepts of mathematics and science to solve problems implies a level of technology literacy and experiences with the use of technology in mathematics and science. This will necessitate a successful and pervasive integration of technology use in both mathematics and science classrooms.

The goals may be viewed as the completed superstructure of the bridge to careers. As with all architectural designs, there are blueprints and foundations and necessary infrastructure. Miami-Dade's bridge to careers will include a blueprint – the curriculum. This bridge will include a foundation – the elementary school program. It will have scaffolding – the middle school program. This bridge must have a powerful infrastructure – a program of professional development and support for teachers. Miami-Dade's bridge will possess a shining superstructure – the senior high program. It is important to consider the recent efforts to improve mathematics and science that have prepared the school system for this venture.

Miami-Dade County Public Schools has benefited from five years of the Urban Systemic Initiative (USI), an extensive program funded by the National Science Foundation (NSF), to produce long-term change in mathematics and science education. Currently, district staff are preparing a proposal to the National Science Foundation for a five-year funding cycle under the Urban Systemic Program grant. The next generation of systemic reform in mathematics and science will be based on the essential features of this district comprehensive plan – *Mathematics and Science Literacy – Bridges to Careers*. While the USI was a K-12 initiative, the focus of the Miami-Dade effort was principally on the elementary school program. Consequently, the majority of resources and staff development activities centered on changing mathematics and science in grades K-5.

Achievement scores on the Mathematics Applications sub-test of the Stanford 8 reached an all-time high, with students at all elementary grade levels matching or exceeding the national median percentile. Science scores also went up at grades 3 and 5, although less substantially. The USI program has had less impact on student achievement at the secondary level. However, student enrollment in higher level courses did increase substantially, especially for minority students, as illustrated by the tables on the following page.

Total and Minority Enrollment in Selected Mathematics Courses, Base Year 1993-94 and 1998-99

Course	African American			Hispanic			All Students		
	Base Year	1998-99	+ Change from Base Year to '99	Base Year	1998-99	+ Change from Base Year to '99	Base Year	1998-99	+ Change from Base Year to '99
Algebra I	5,127	13,674	167%	8,730	21,742	149%	17,339	40,550	134%
Geometry	2,681	5,799	116%	5,035	9,595	91%	10,114	18,638	84%
Algebra II	2,064	3,881	88%	3,866	6,427	66%	8,179	13,012	59%
Pre-Calculus	458	947	107%	959	2,182	128%	2,110	4,368	107%

Total and Minority Enrollment in Selected Science Courses, Base Year 1993-94 and 1998-99

Course	African American			Hispanic			All Students		
	Base Year	1998-99	+ Change from Base Year to '99	Base Year	1998-99	+ Change from Base Year to '99	Base Year	1998-99	+ Change from Base Year to '99
Physical Science	6,641	8,441	27%	10,291	14,181	38%	20,618	26,578	29%
Biology	5,763	7,314	27%	9,387	11,993	28%	18,451	22,876	24%
Chemistry	2,532	3,535	40%	4,122	5,469	33%	8,969	11,502	28%
Physics	635	797	26%	1,573	1,896	21%	3,255	3,754	15%

Many hours of professional development have produced episodic changes in numerous classrooms, and have developed an excellent core group of teacher leaders. The type of sustained improvement in teaching practices that is necessary to accelerate student achievement at the secondary school level requires a renewed and more focused effort. This effort will concentrate on improving teaching practice.

It is essential to emphasize that the centerpiece for improved learning is excellent teaching. The daily work of classroom teachers in Miami-Dade Public Schools will be the single most powerful determinant of student success in mathematics and science and therefore the success of any plan to accelerate student ability to use mathematics and science in a meaningful context. A structured approach to improving capacity of teachers to teach the mathematics and science and to transforming teaching practices is the key to success.

Mathematics and science reform efforts, and the higher academic standards included in those efforts, require far-reaching and difficult changes in the practice of teaching mathematics and science. The new vision is one in which all students are engaged in

inquiry-based instruction and discovery. The students of Miami-Dade County Public Schools must acquire the ability to effectively problem solve, the ability to make real-world applications, and have a deep conceptual understanding of the content within these disciplines. These are compelling necessities not only for public accountability, but also for the public need for a competent workforce. To achieve this vision for every classroom and every student, teachers need new knowledge, skills, and behaviors. Therefore, teachers need opportunity for appropriate professional growth that nurtures the intellectual and leadership capacity of teachers and focuses on individual, collegial, and organizational improvement. The following seven principles should guide all professional development activities to ensure a positive impact on student learning and achievement:

1. Effective professional development experiences are driven by a well-defined image of effective classroom learning and teaching. This should include commitment to all children learning mathematics and science: an emphasis on inquiry-based learning, investigations, problem solving and applications of knowledge. Teachers should develop approaches that emphasize in-depth understanding of core concepts and challenge students to construct new understandings, and use assessment practices that measure meaningful achievement.

2. Effective professional development experiences provide opportunities for teachers to build knowledge and skills that not only include development of in-depth knowledge of subject matter, but also include applications of technology to enhance the curriculum and effective pedagogy.

3. Effective professional development experiences use or model with teachers the strategies teachers will use with their students. For example, they start at the point where teachers are and build from there. They provide ample time for in-depth investigations, including the use of technology to increase their proficiency, collaborative work, and reflection; and connect with teachers' other professional development activities.

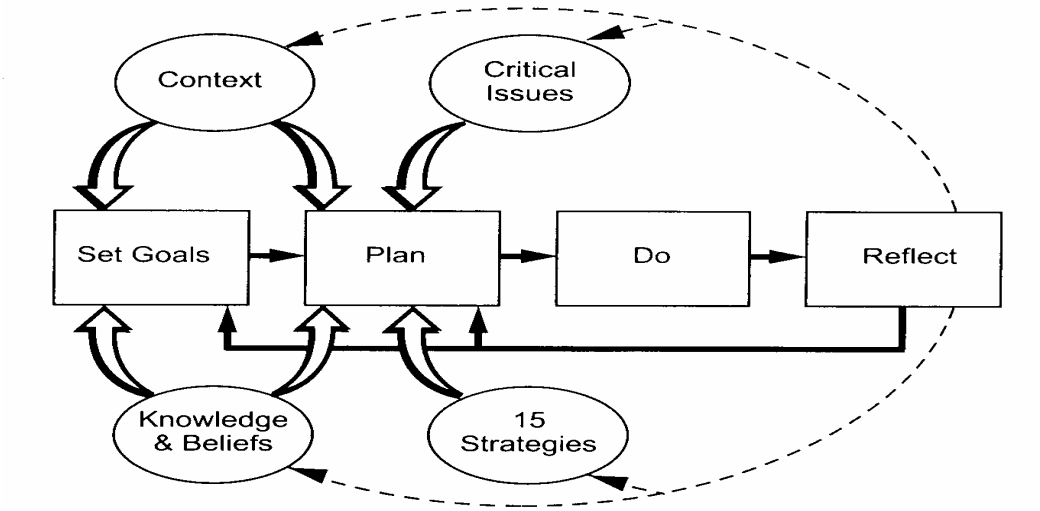
4. Effective professional development experiences build a learning community. Continuous learning becomes part of the school norms and culture; teachers are rewarded and encouraged to take risks and learn, and teachers learn and share together.

5. Effective professional development experiences support teachers to serve in leadership roles as supporters of other teachers, as agents of change, and as promoters of continuous improvement in teaching and learning.

6. Effective professional development experiences provide links to other parts of the education system. Professional development should be integrated with other district or school initiatives, state and national standards and assessments; and have active support within the community.

7. Effective professional development experiences are continuously being assessed and being improved to ensure a positive impact on teacher effectiveness, student learning, leadership, and the school community.

Prior to the late 1990's many professional development experiences brought outside expertise to teachers to increase strictly content knowledge. More recently, research has indicated that these experiences must not only include the teacher but also focus on the school as a whole, and are likely to have a greater impact on practice if tailored to the specific school site. School-site ownership of the professional development agenda that reflects the critical priorities of how each school can maximize student achievement is a necessary ingredient of sustainable improvement in teacher practice. Previously, there has been little direction about how to design professional development so that it promotes continuous learning in the organization, provides equity for teachers and students, builds the capacity of teachers, fits within the school context, and gives teachers the range of experiences they need to learn. Currently, Miami-Dade County Public Schools is implementing the Professional Assessment and Comprehensive Evaluation System (PACES). In PACES, teachers enter into a professional development process with colleague teachers, administrators, and/or district subject area specialists. The results are developed into a personal professional portfolio for review, recommendation and discussion, and therefore produce professional growth. The following design framework organizes the components of effective professional development into a process of planning and action that models the objectives of PACES.



Professional Development Design Process for Mathematics and Science Reform (Adapted from *Designing Professional Development for Teachers of Science and Mathematics* by Susan Loucks-Horsley, et al., 1998)

At the center of the framework is a generic planning sequence incorporating goal setting, planning, doing, and reflecting. Knowledge and beliefs, context, critical issues, and strategies represent important inputs into both goal setting and planning that can help teachers make informed decisions about effective classroom instruction. These

features are at the center of PACES and will become important M-DCPS benchmarks for teacher development.

Research suggests that effective professional development in mathematics and science involves an active study of effective teaching and learning practices. It is important to attend to individual teacher needs and provide learning opportunities. Over time this develops a climate of collegiality combined with a capacity for continuous learning and support. Full implementation of PACES combined with the active school-site support proposed in this plan provides excellent conditions for maximizing teacher effectiveness.

It is intended through *Mathematics and Science Literacy – Bridges to Careers* that all Miami-Dade County public schools implement a *Transformative Learning Model* of professional development at each school site through school-site mathematics and science instructional improvement teams. Educational specialists that are assigned to feeder patterns will facilitate the teams by modeling lessons, deepening content knowledge, and implementing the use of best practices. The Professional Development Design Process illustrated on page 5 will be the vehicle that guides this course of action. This model of professional development is a guide to the implementation of the PACES competencies.

The Professional Development Design Process should be followed by an analysis of the context in which teachers teach their students to learn. Miami-Dade is a culturally diverse community; therefore it is essential that the needs of all M-DCPS students be met. Limited English proficient (LEP) students are expected to master the mathematics and science curriculum at the same pace as other students. Therefore, teachers must have an opportunity to implement effective teaching and learning strategies for LEP students as well as all students with special learning needs. A careful examination of student work provides an opportunity for teachers to understand student thinking so that appropriate instructional strategies and materials can be utilized. Each of these elements is consistent with PACES and will be designed to assist teachers to effectively teach all students. A well-chosen array of experiences for teachers, in many areas of knowledge and skills, within multiple contexts will maximize a teacher's opportunity for professional growth.

A combination of increased mathematics and science course requirements, predicted teacher retirements, and the general attrition of mathematics and science teachers creates a dramatic need for the acquisition of more mathematics and science teachers to staff the classrooms of Miami-Dade County public schools. A master plan to increase the number of certified graduates prepared to teach science and mathematics, in collaboration with the local universities, is necessary and desirable.