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ABSTRACT

The purpose of this study was to identify current educational reform issues that would increase student achievement in mathematics and science in South Texas middle schools, specifically grades 4-8. Areas of research included common teacher and student needs, state and national standards in mathematics and science, competent teaching practices, and strategies of professional development. The target population of the study was grades 4 through 8 mathematics and science teachers in the state of Texas. Twenty-five (25) schools from Texas Education Regions 1, 2, 3, and 20 were randomly selected to receive surveys. The 100 selected schools yielded approximately a sample population of 350 teachers. Fifty-six (56%) of the targeted schools returned surveys resulting in a survey response rate of 51% (177 surveys). The instrument used was a self-developed survey. It solicited responses concerning subject(s) and grade levels taught, knowledge of state and national standards, professional development, effective teaching practices, and technology. Descriptive statistics included a breakdown of teacher responses to each item on the questionnaire utilizing both raw data and percentages. Each result was discussed in relation to the original question with additional discussion given when a significant difference was noted. The results indicated that there is a wide discrepancy in content knowledge, instructional methodologies utilized, program implementation, and hours of content related professional development activities between mathematics-only, science-only, and mathematics and science teachers. Mathematics teachers rated their abilities associated with content, curriculum standards, and program implementation higher than science teachers did. In general, survey results indicated a greater need in the area of science education than mathematics education and for teachers who teach both mathematics and science respectively, than for single subject teachers. The literature review and survey responses indicated hands-on activities as the most important factor when creating the ideal classroom, but responses indicated that seatwork was used most frequently. Teachers indicated that technology was important; however, it was one of the instructional methodologies utilized least frequently. The study identified three components that would enhance reform in middle school mathematics and science in South Texas. First, implement interdisciplinary teaming. Second, implement varied instruction including integration of learning experiences. And finally, implement exploratory programs exposing students to a range of vocational, academic, environmental, and recreational areas. The study

identified the following practices as necessary to enhance mathematics and science middle school reform in South Texas. The curriculum should demand depth of a significant core of skills and emphasize the development of the students' reasoning abilities and problem solving abilities. Teaching should incorporate hands-on activities and the tools of technology. Finally, assessment needs to involve interdisciplinary tools. The study found that professional development must incorporate the following initiatives to secure effectiveness: teachers must be the key to student learning; teachers must develop further expertise in content areas; development should focus on implementing effective teaching methodologies; teachers should have the opportunity to develop and plan collaboratively; and professional development should be sustained, ongoing, intensive, and fully supported by the administration. (Contains 43 references.) (ASK)

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Executive Summary

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Descriptive statistics included a breakdown of teacher responses to each item on the questionnaire utilizing both raw data and percentages. Each result was discussed in relation to the original question with additional discussion given when a significant difference was noted.

The results indicated that there is a wide discrepancy in content knowledge, instructional methodologies utilized, program implementation, and hours of content related professional development activities between mathematics-only, science-only, and mathematics and science teachers. Mathematics teachers rated their abilities associated with content, curriculum standards, and program implementation higher than science teachers did. In general, survey results indicated a greater need in the area of science education than mathematics education and

for teachers who teach both mathematics and science respectively, than for single subject teachers.

The literature review and survey responses indicated hands-on activities as the most important factor when creating the ideal classroom, but responses indicated that seatwork was used most frequently. Teachers indicated that technology was important; however, it was one of the instructional methodologies utilized least frequently.

The study identified three components that would enhance reform in middle school mathematics and science in South Texas. First, implement interdisciplinary teaming. Second, implement varied instruction including integration of learning experiences. And finally, implement exploratory programs exposing students to a range of vocational, academic, environmental, and recreational areas.

The study identified the following practices as necessary to enhance mathematics and science middle school reform in South Texas. The curriculum should demand depth of a significant core of skills and emphasize the development of the students' reasoning abilities and problem solving abilities. Teaching should incorporate hands-on activities and the tools of technology. Finally, assessment needs to involve interdisciplinary tools.

The study found that professional development must incorporate the following initiatives to secure effectiveness. Teachers must be the key to student learning. Teachers must develop further expertise in content areas. Development should focus on implementing effective teaching methodologies. Teachers should have the opportunity to develop and plan collaboratively. Finally, professional development should be sustained, ongoing, intensive, and fully supported by the administration.

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Chapter I

Introduction

Fisher (1998) stated that based on the results of the Third International Mathematics and Science Study (TIMMS), U.S. fourth graders did quite well in science compared with their peers around the world. The fourth graders scored significantly better than 19 of the 26 countries that participated. However, the performance of U.S. students declined drastically by the eighth grade, dropping to twelfth place. By the end of high school, the results were devastating. American high school seniors were among the industrial nations' poorest performers in both science and mathematics, out performing only Cyprus and South Africa. Even the brightest U.S. students, those taking advanced mathematics and physics, performed poorly against the top students from other nations, beating only Austria in advanced mathematics while at the same time ranking last in physics. Only 49% of U.S. public school science teachers and only 53.5 % of mathematics teachers are certified in their areas, according to the 1993-1994 School and Staffing Survey completed by the Department of Education's National Center for Education Statistics (cited in Fisher, 1998).

The majority of students graduating today do not have adequate skills in mathematics, science, and technology to become competitive players in the global job market according to the Association for Computing Machinery (ACM, 1999). The ACM has identified six basic problems that must be addressed to increase skills in mathematics, science, and technology: 1) the curriculum; 2) teacher preparation; 3) parental support; 4) community involvement; 5) equity; and 6) the lack of resources. Curriculum standards that are being applied in South Texas do not align with these industrial needs. ACM further stated that teachers with mathematics, science, and technology skills are not choosing to be teachers. Existing teachers are not

receiving effective professional development in order to improve. Parents need instruction in learning how to help their children, and teacher feedback on student progress. Community resources are often underutilized.

Schoen, Fey, Hirsch, and Coxford (1999) noted many schools reject opportunities for much-needed improvement in mathematics education and continue with comfortable and conventional, though demonstrably inadequate, curricula, teaching, and testing practices. When the National Council for Teachers of Mathematics (NCTM) formulated its standards for curriculum and evaluation, teaching and teacher education, and assessment of students and programs, there was a broad consensus that major change was needed in each aspect of school mathematics. There was further agreement on the specific reforms that should be adopted. That consensus was developed through the study of teaching practices in other countries along with a vision of an even more effective mathematics education and through a broad consultation with people who use mathematics in the workplace. It was shaped by the results of recent research on teaching and learning, and by analyses of prospects for new technologies in teaching, learning, and doing mathematics; and by the experience-based wisdom of practice of many outstanding teachers. These reform proposals focused on issues of mathematical content, teaching strategy, and testing practices.

Problem

Low student achievement in mathematics and science has become a major concern. McKain (1999) stated that trends in U.S. students' academic performances in science and mathematics showed a decline over the past 25 years. United States students performed at high levels in fourth grade, but by the time they approached high school graduation they were performing at unacceptably low levels in both mathematics and science (U.S. Department of

Education, 1998). Few districts have implemented staff development activities that were guided by a coherent vision of what students should know and should be able to do (Lewis, 1995). Nothing less than the future is at stake. The present world leadership in technology and economic well being threatens to erode entering the 21st century, because children are ill prepared to compete in a global high technology marketplace (Fisher, 1998). However, effective implementation of educational reform can improve student achievement. Fisher further identified innovations specific to science and mathematics schooling that can be implemented across the economic and social spectrums. One innovation is to improve the content and pacing of what is taught, or curriculum reform. The other is a better-trained teacher, both in his/her field(s) of expertise and in the methodology of how mathematics and science needs to be taught.

Purpose of the Study

The purpose of this study was to identify current educational reform issues that increase student achievement in mathematics and science in Texas middle schools. The study included the analysis of mathematics and science curriculum standards and reforms, applicable teaching practices, and implementation of effective professional development. The specific research questions of this study were:

1. What are the perceived needs for educational reform in the areas of middle school mathematics and science?
2. What are the common components of national and state middle school mathematics and science curricular standards?
3. What are the common components of current middle school reforms in mathematics and science education?
4. What components are considered when developing applicable teaching practices?

5. What components are considered when implementing reformed-based professional development programs?
6. What are the components of an effective mathematics/science middle school?

Limitations of the Study

This research was limited when considering the factors of time, population, and the lack of statistical research data previously conducted in the problem area. This research was conducted over a time period of approximately five months. Additional time would have facilitated a higher percentage of returned surveys. The population was limited to four South Texas educational regions: Region 1, Region 2, Region 3, and Region 20. The Review of Literature included a wide scope of classroom observations and national and international testing; however, quantitative statistical data was very limited in the areas of middle school mathematics and science reform.

Importance of the Study

Some call it the black hole, those middle school years when children seem hard to reach and too hard to teach. Yet there is no more critical time for children than the years from 11 to 14. What they learn during this time sets the tone for the important high school years on the horizon (Houtz, 1998). Many children succeed or fail in the middle grades. Either they acquire the academic knowledge and skills they need to achieve in high school and life, or they fall so far behind they drop out or drift through high school with little hope of a successful future (Focused Reporting Project, 2000). The middle grade years are extremely important but are virtually ignored when compared to the elementary and high school years. Education "in the middle" has traditionally received scant attention from either school systems or communities. Many school

boards and superintendents know little about the developmental and learning needs of young adolescents. Communities worry more about student behavior than about what the children are learning (The Edna McConnell Clark Foundation, 1997). This research will identify the components of an effective mathematics and science middle school educational program. Through the implementation of effective components, mathematics and science achievement of middle school students in South will improve.

Definition of Terms

The following terms will have controlled meanings and are herein defined for this study.

1. Educational reform is defined as high academic expectations for all students and the teaching of high content and skills that will enable students to transfer across curricular disciplines and to apply to real-life situations.
2. Standards are defined as the criteria of excellence intended to improve student achievement in mathematics and science as well as the facilitator for directing educational reform.
3. Middle School is defined as encompassing grades 4 – 8 specifically for this study. This study recognizes that there are many different grade level configurations for middle school.
4. TAAS is defined as the Texas Assessment of Academic Skills.
5. Pedagogical teaching is defined as teaching with the goal of protecting and teaching the young to live in the world and to take responsibility for themselves (van Manen, 1991).
6. Interdisciplinary teaching is defined as the deliberate attempt, through specific instructional activities, to connect ideas and procedures between and across content areas of curriculum.
7. Team teaching is defined as the organization of teachers into teams working with smaller clusters of the same students.

Chapter II

Review of Literature

Introduction

Two main messages emerge from the results of the Third International Mathematics and Science Study (U.S. Department of Education, 1998). First, U.S. students do not start out behind; they fall behind. The United States is the only TIMSS nation that went from above average in mathematics in fourth grade to below average in eighth grade. By the time students complete their formal secondary schooling, they are not achieving at the international standards demanded by a global labor market (U.S. Department of Education, 1998). The TIMSS data can help give national urgency and focus to U.S. school improvement efforts. There clearly needs to be a dramatic, rapid, and fundamental improvement in mathematics and science education, particularly in our middle schools and high schools. This review of literature identified current practices with middle school mathematics and science education, as well as, effective components leading to middle school reform in mathematics and science. The review was sectioned in conjunction with the first five research questions described in Chapter 1: The Purpose of the Study. The sub-sections are Educational Reforms, National and State Standards, Middle School Reforms, Teaching Practices, and Professional Development.

Educational Reforms

How important is it for America to initiate educational reform in the academic fields of mathematics and science? The reform of K-12 mathematics and science education is now recognized in many countries as a vital national interest linked to economic competitiveness, national security, environmental concerns and other educational issues (Thomas, 1995). The

National Science Foundation (NSF) Director, Dr. Neal Lane (1995) testified in Congress before the House Science Subcommittee that future employers will need workers who are not only well versed in science and technology concepts, but who are adept to learning through experimentation, inquiry, critical evaluation and discovery. As society continues to travel down the path of advanced technology the conceptualization of mathematics and science skills are extremely crucial in order to prepare youth to become globally competitive.

Is America successfully preparing its youth in mathematics and science? A majority of students graduating today do not have adequate skills in mathematics, science, and technology to become competitive players in the global job market (ACM, 1999). In virtually every assessment of mathematics and science achievement since the early 1980s, American students have lagged well behind the top-performing countries and below international averages (Pong, 1997; Bohrnstedt; 1997). Apparently America is not preparing its youth in these two crucial areas. The severity of this problem is so apparent that Presidents Bush and Clinton chose to include the reforms of mathematics and science in the National Education Goals. Goal Five stated that by the year 2000, the United States would be the first in the world in mathematics and science achievement (Goal 2000: Educate America Act, 1994). Statistics concerning the failure of mathematics and science achievement become even more discouraging when compared to a 1991 international reading assessment where 14 year-old U.S. students scored near the top among the countries tested (National Center for Educational Statistics, 1991).

The need for improvement has been acknowledged; however, in order to achieve educational reform three areas need to be addressed: student needs, curriculum, and teacher quality. The middle school student's needs are among the most important considerations when examining reforms in education. Schools must be "developmentally appropriate". Advocates

for middle schools have insisted on school structures that foster a sense of belonging, confidence, and self esteem in young adolescents, and that support multifaceted learning, meaningful participation in school life, and positive social interaction with adults and peers (Wheelock, 1995). Through these difficult and awkward years, the middle school student needs the understanding and support of schools in order to achieve maximum potential.

The curriculum and teaching methodologies in mathematics and science are also a concern. Silver (1998) stated that the mathematics curriculum has been criticized for the following. The U.S. school mathematics curriculum is unfocused. More topics are included in the U.S. curriculum at each grade level than are found in the curricula of most other countries. The U.S. school mathematics curriculum is not sufficiently demanding. Silver further noted that compared to many other countries, the content taught at grade 8 in the United States is similar to the content taught at grade 7 elsewhere, and the performance expectations are lower in the U.S. When discussing science curriculum, the National Academy of Sciences (1994) stated that learning would be better achieved when students are actively engaged in inquiry activities developing investigative abilities and understandings rather than by having the students memorize the abilities and understandings. Mathematics and science curriculums need to be reassessed to assure effectiveness.

The quality of teacher preparedness must also be considered. Only 49% of U.S. public school science teachers and only 53.5% of mathematics teachers were certified in their teaching areas according to the 1993-1994 School and Staffing Survey completed by the Department of Education's National Center for Education Statistics (cited in Fisher, 1998). Lack of certification is a direct link to poor student achievement. While national and state standards and district curriculum frameworks can give general guidance, teachers make the final decisions for

day-to-day instruction (Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching, 1998). If the final decision of instruction is the teacher's, then adequate training and certification is a must.

Fisher (1998) concluded that mathematics and science education is crucial in a child's academic endeavors. It is America's duty to guarantee an effective exposure to these areas in order to secure a future that allows children to become globally competitive.

National and State Standards

History and Background of Standards Movement

To affect change, sustain reform, and improve education across the diverse U.S. educational system, there must be a common vision. This vision must be founded on a cohesive set of ideas, built from a consensus of perspectives, communicated broadly, and implemented with commitment (National Academy of Science, 1998).

In response to the low performance of U.S. students in international achievement studies, President Bush called for the establishment of national standards that would improve student achievement in mathematics and science. These standards were to function as "criteria for excellence" as well as "facilitators for reform" (Hiebert, 1999). Standards-based reform would involve high academic expectations for all students. Skills that transfer across disciplines and to real-life situations would be developed.

Recommendations found in the standards are deliberately ambitious. It is worse to underestimate what students can learn than to expect too much (American Association for the Advancement of Science, 1996). To improve student learning, it would be necessary to analyze what is taught (the curriculum) and how it is taught (instruction and teaching practices). The standards would involve "learning for understanding" on two dimensions: (a) content which would be based on important and enduring concepts in mathematics and science and (b)

cognitive processes which would enable students to use the facts and concepts (Wheelock, 1995, 1996).

In the early 1990's the U.S. Department of Education awarded grants to professional organization to develop academic standards that would shape curriculum reform. National organizations developed standards in the areas of mathematics, science, English and social studies. The standards delineated what students should know and be able to do. They were based on a broad, informed, coherent vision of schooling derived from current knowledge, societal goals, student goals, research on teaching and learning, and professional experience (National Council of Teachers of Mathematics, 1989; Wheelock, 1995; Hiebert, 1999). Standards in Mathematics, Science, English, and Social Studies shared several common components: identification of global concepts; use of higher-order cognitive processes as well as "basic skills" to make sense of concepts; and an inquiry-based curriculum focusing on thinking skills, problem-solving, making connections, and communicating (Wheelock, 1995).

In the areas of mathematics and science, several major projects emerged as leaders in the standards field. The projects included the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics, 1989; the NCTM: Principles and Standards for School Mathematics. 1999; the American Association for the Advancement of Science (AAAS), Project 2061: Science for All Americans, 1999; and the National Academy of Science, National Science Education Standards, 1995.

In addition to national standards, states developed guidelines describing what students should know and would be able to do in courses taught in public schools. In 1998, the state of Texas adopted the Texas Essential Knowledge and Skills (TEKS), which replaced the Essential Elements (EEs). The Essential Elements focused on what teachers were to teach while the TEKS

focused on students. Developed by the Texas Education Agency (TEA), the TEKS were organized into grade level clusters: Elementary (K-Grade 5), Middle School (Grades 6-8), and High School (Grades 9-12). The TEKS became effective September 1, 1998. Chapter 111 of the Texas Education Code described the Mathematics TEKS while Chapter 112 described the TEKS that applied to science.

National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics, 1989

In the late 1980's the Commission on Standards for School Mathematics was established by the National Council of Teachers of Mathematics (NCTM) and charged with two tasks. The first was to create a coherent vision of what it meant to be mathematically literate in a world that relies on calculators and computers, and where mathematics was rapidly growing and was extensively being applied in diverse fields. The second was to create a set of standards to guide the revisions of the school mathematics curriculum and its associated evaluation toward this vision (NCTM, 1989).

Eight years in development, the result was "The National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics, 1989". The NCTM Standards were created to improve the teaching and learning of mathematics by functioning as a vehicle for the fundamental restructuring of the curriculum and instructional methods. The guiding philosophy was mathematics as an "active, constructive process" with students involved in solving problems, communicating, and reasoning. Instruction was based on real problems and evaluation used to improve instruction, learning, and programs. To meet the demands for mathematically literate citizens, teachers and students should spend an hour a day on mathematics at all grades (NCTM, 1989).

In order to develop mathematically literate workers and informed citizens, capable of understanding issues in a technological society, five broad standards were identified. Students would learn to value mathematics; become confident in their ability to do mathematics; become mathematical problem-solvers; learn to communicate mathematically; and learn to reason mathematically (NCTM, 1989; Wheelock, 1995). The standards were not intended to be a scope-and sequence but a framework for teacher-directed curriculum development. The challenge for educators would be to develop a curriculum for all (women, minorities, gifted/talented, less-able students) that includes a broad range of content, a variety of contexts, and deliberate connections to other subjects (NCTM, 1989). Standards should cause teachers to reflect on the content of the mathematics they teach, how they teach it, and how it is assessed (Wheelock, 1995,1996).

The mathematics standards were based on three grade level clusters: K-Grade 4, Grades 5-8, and Grades 9-12. The focus of the K 4 curriculum was on helping children understand and interpret their world and to solve problems that occur in it. Through the exploration of mathematical concepts through child-centered real-world experiences, abstractions emerge and mathematical understandings and relationships would be developed. Children would be encouraged to explore, develop, test, discuss, and apply ideas. While the emphasis is on the development of mathematical thinking and reasoning abilities, skill acquisition, development of problem solving strategies, and development of confidence in ability to think and communicate mathematically would be integral components. In addition to arithmetic, measurement, geometry, statistics, probability, and algebra topics are utilized (NCTM, 1989).

The focus in Grades 5-8 was on problem solving and the usefulness of mathematics. The abilities of students to solve problems, reason logically, explore and make sense of their world

would be developed. Integrated topics such as computations, estimation, measurement, geometry, statistics, probability, patterns and functions, and the fundamental concepts of algebra would be explored. Activities, focusing on communicating about mathematics concepts and reasoning, as well as the use of calculators and computers in problem solving situations would be included (NCTM, 1989).

Compared to the traditional mathematics curriculum, NCTM Standards required less emphasis on: (a) rote aspects of learning (memorizing rules, algorithms, and procedures such as cross-multiplication, without understanding); (b) practicing repetitive paper-and-pencil computations, and rounding numbers out of context; (c) individual practice; and (d) cut-and-dried, right-answers. In a restructured curriculum, more emphasis would be placed on: (a) developing number and operation sense; (b) creating mathematical procedures; (c) using estimations and checking reasonableness in problem solving; (d) exploring relationships among whole numbers, fractions, decimals and integers; (e) understanding ratios, proportion, and percent; and (f) discussing ideas, reasoning, and solution strategies (NCTM, 1989; Wheelock, 1995).

In addition to content and processes, the NCTM Standards prescribed changes in mathematical instructional methods. These included: (a) studying mathematics in contexts that give meaning to ideas and concepts; (b) using problems that arise from situations that are not always well formed; (c) providing opportunities for students to formulate problems and questions that stem from their own interests; (d) learning what engages students both intellectually and physically; (e) hands-on activities involving tactile, auditory, and visual instructional modes; (f) opportunities to communicate and reason mathematically by listening to and talking about mathematics with peers; (g) collaborative, cooperative, and, independent work; (h) creating an

environment in which students feel free to explore mathematical ideas, ask questions, discuss their ideas, and make mistakes; and (I) taking positive advantage of the social characteristics of the middle school student (NCTM, 1989).

Fisher (1998) identified the use of calculators and computers as the most controversial aspect of the standards. This "whole mathematics" approach de-emphasized calculation skills and stressed the ability to grasp and represent spatial and quantitative relationships. Implemented correctly, the standards do not abandon learning mathematics fact but allow the focus of mathematics to be more than memorization of facts. Use of technology in mathematics was also supported by Schoen et al (1999). Calculators and computer use for numeric and graphic mathematical calculations would result in less focus on procedural skills; less instructional time devoted to training students in paper and pencil operations, and more rapid and accurate numerical results.

Principles and Standards for School Mathematics (NCTM, 1999)

In 1998, NCTM revisited the original standards and developed the Principles and Standards for School Mathematics, which addressed standards relating to performance, process, and content standards. Significant changes between the two documents included the narrowing of the grade spans from three sections (K-Grade 4, Grades 5-8,and Grades 9-12) to four sections (K-Grade 2, Grades 3-5, Grades 6-8, and Grades 9-12) and an increase from five to ten content standards. The ten new content standards included: (1) number and operation sense; (2) patterns, functions, and Algebra; (3) geometry and spatial sense; (4) measurement; (5) data analysis, statistics, and probability; (6) problem solving; (7) reasoning and proof; (8) communication; (9) connections; and (10) representation (NCTM, 1999).

According to the NCTM (1999), the mathematics curriculum should be a plan for instruction. That plan should identify what mathematics students need to know, how students are to achieve the identified curricular goals, what teachers are to do to help students develop their mathematical knowledge, and the content in which teaching and learning best occurs. The mathematics curriculum should translate the standards into activities that focus on learning through active involvement in mathematics. Students should regularly experience genuine problems, search for answer to questions, generalize, and justify findings. Student products, projects, exhibitions, and essays that demonstrate an understanding of the standards should be displayed for peers, parents, and the community to view (Wheelock, 1995; NCTM, 1999).

The focus of the standards needs to be on problem solving. Less emphasis is placed on practicing routine, one-step problems and more emphasis is given to extended problem-solving projects and formulating and investigating questions from problem situations (Wheelock 1995). According to Hiebert (1999), problem solving must be central to schooling so students can explore, create, accommodate to changed conditions, and actively create new knowledge over the course of their lives. Rather than being taught a procedure and then being assigned problems on which to practice the procedure, students acquire skills while developing them through problem solving. The development of the skill itself is treated as a problem for students to solve. Schoen et al (1999) noted that most students learn better from a curriculum that develops key ideas from work on concrete problems in meaningful real-life contexts.

The NCTM (1989; 1999) noted that an emphasis of learning through problem solving is consistent with widespread concern that students acquire the ability to apply mathematical ideas and techniques to problem solving and decision making in other fields of work. In Grades 3-5, NCTM found that the volume of mathematical content expands and students develop

computational fluency. The goal is for students to make sense of mathematical ideas, acquire skills and insights to solve problems, and build connections to manage new concepts and procedures. Students examine, ask questions, and consider different strategies. Critical components include the efficient recall of basic facts, opportunities to develop personal strategies for computation, and a view of algorithms as tools for solving problems rather than the goal of mathematics study. NCTM concluded that whole number instruction should be completed by the end of Grade 5. A key dimension in this grade span is the transition from whole numbers to fractions and decimals, which focuses on establishing a conceptual understanding of fractions and not computations. Success at later grades depends largely on the quality of the foundation that is established during the first five years of school.

The curriculum in Grades 6-8 establishes a solid mathematical foundation. During this period, students form conceptions about themselves as mathematical learners including interest, competence, attitude, and motivation. These conceptions influence how they approach mathematics in high school, which will influence life opportunities It is essential for students to: (a) find challenge and support in the classroom; (b) regularly engage in thoughtful activity that relates to finding and imposing structure, conjecturing, verifying, abstracting and generalizing; (c) regularly experience interesting tasks that promote thinking, reasoning, and problem solving; and (d) learn serious, substantive mathematics in classrooms where the emphasis is on thoughtful engagement and meaningful learning (NCTM, 1999).

During Grades 6-8, the emphasis is on rational, not whole numbers, with students developing fluency with fraction computations. Students think flexibly about relationships among fractions, decimals, and percent. The development of proportional reasoning is a key aspect. Experiences should include work with ratios, proportions, percent, similarity, equality,

variable, symmetry, scaling, linear equations, area, volume, slope, sales tax, data distributions, and probability. Without acceleration or specialization, fluency with basic algebraic concepts and skills should be developed. In a traditional algebra program, students have less opportunity to learn the full range of mathematics content, especially topics in geometry and data analysis (NCTM, 1999).

Instructional methods focus on the application of mathematics to a real-world situations rather than teaching computations and drills out of context. Instruction is varied and includes opportunities for: (a) project work; (b) group, individual and cooperative learning assignments; (c) discussions between teacher and students and among students; and (d) using concrete materials and appropriate technology for computation and exploration (NCTM, 1999).

Standards-based reform creates a challenging classroom by enriching the curriculum content and by expanding access to improved learning to all students, especially those who have been traditionally excluded from such learning (Wheelock, 1995, 1996). The NCTM Standards are designed to increase the participation, enthusiasm, and success of a much wider range of students. According to the NCTM Standards, mathematics proficiency for the middle school student means being able to apply knowledge of mathematics facts and concepts to reason, communicate, and solve problems (Wheelock, 1995).

Project 2061: Science for All Americans

Current methods of instruction inhibit progress toward science literacy. Current methods emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, pieces of information instead of understandings in context, recitation over argument, and reading in lieu of doing. Students are not encouraged to work together, to share ideas and information freely with each other, or to use modern instruments to extend their

intellectual capabilities. A scientifically literate person is one who understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes (AAAS, 1999).

The American Association for the Advancement of Science (AAAS, 1999) selected representatives from science, mathematics, and technology communities to develop standards that would foster scientific literacy among all students. After a two-year process, Project 2061: Science for All Americans emerged. The goals of this vision included: (a) appropriate use of scientific principles to make personal decisions; (b) excitement and rich experiences in knowing about the natural world; (c) increased economic productivity; and (d) intelligent public discourse and debate about matters of scientific and technological concern (AAAS, 1999; Wheelock, 1995, Manning 1998).

Project 2061 (cited in Manning, 1998) identified scientific knowledge, skills, and attitudes that all students should acquire. Teachers were encouraged to begin lessons with questions about nature, to engage students intellectually and physically, to concentrate on the collection and use of evidence, to provide historical perspectives, to use team and interdisciplinary approaches, and to de-emphasize memorization. Rather than teaching more content (quantity), the focus was on effectively teaching what is essential to science literacy (quality). By concentrating on fewer topics and introducing ideas gradually and in a variety of contexts, students acquire richer insights and deeper understandings than they would gain from a superficial exposure to more topics than can be assimilated. The problem for curriculum developers is to decide what to eliminate, rather than what to add (Manning, 1998; Wheelock, 1995).

Content should focus on human life, be worth knowing decades from now, and serve as a foundation on which to build more knowledge over a lifetime. (AAAS, 1999). Attention to life, physical, and earth science is balanced with attention to learning processes such as inquiry and science for personal and social decision-making. This balance moves science learning away from memorization to learning for greater understanding. Areas for study include: (a) science as inquiry; (b) life science; (c) science and technology; (d) history and nature of science; (e) physical science; (f) Earth and space science; and (g) science in personal and social perspectives (Wheelock, 1995).

Integration of mathematics, science and technology is encouraged. Science provides mathematics and technology with interesting problems to investigate, and mathematics and technology provides science with powerful tools to use in analyzing data. Science, technology, and mathematics are trying to discover general patterns and relationships are based on an understandable order, and involve imagination as well as logic. Mathematics is the chief language of science (AAAS, 1999).

National Science Education Standards

Teachers, school administrators, parents, curriculum developers, college faculty and administrators, scientists, engineers, and government officials developed the National Science Education Standards. These standards, along with a description of the vision of a scientifically literate populace, were developed based upon earlier reform efforts, research on teaching and learning, accounts of exemplary practice, and personal experience and insights. The Standards were organized into six chapters: teaching, professional development, assessment, content, education programs, and education systems (National Academy of Science, 1995).

The standards outlined what students at different grade levels needed to know, understand, and be able to do in order to be scientifically literate. They described an educational

system in which all students demonstrate high levels of performance and in which teachers are empowered to make the decisions essential for effective learning. The Standards embody excellence and equity for all students. All students need access to skilled professional teachers, adequate classroom time, a rich array of learning materials, accommodating workspaces, and the resources of the communities surrounding their schools.

Effective teaching was a critical component of the standards. Good teachers of science create environments in which they and their students work together as active learners. The science teaching standards describe what teachers of science at all grade levels should know and be able to do in six areas: (1) planning of inquiry-based programs; (2) guiding and facilitating student learning; (3) assessing teaching and learning (4) developing environments that facilitate learning; (5) creating communities of learners; and (6) planning and developing school science programs

The standards represent a change from traditional science teaching. The standards place less emphasis on: (a) scientific facts and information; (b) separating science knowledge and science process; (c) covering many science topics; (d) implementing inquiry as a set of process skills; and (e) providing answers to questions. More emphasis is placed on: (a) a deeper understanding of fewer scientific concepts; (b) integrating all aspects of science content; (c) developing inquiry skills to investigate and analyze science questions rather than demonstrate or verify science content; (d) using multiple process skills during long-term investigations; (e) analyzing data, and synthesizing and defending conclusions during group work; (f) doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content; (g) public communication of student ideas and work to classmates (National

Research Council, 1996); and (h) using thinking skills over specialized vocabulary and memorized procedures (Manning, 1998).

The Standards are not a curriculum guide but provide criteria for judging whether particular actions will serve the vision of a scientifically literate society. Topics are clustered into three grade levels (K- Grade 4, Grades 5-8, and Grades 9-12) and are divided into seven Content Standards. The standards identify what students should know, understand, and be able to do in the natural sciences over the course of K-12 education. Content Standard A, Science as Inquiry, prescribed frequent scientific inquiries for all students. As a result of Science Content Standard B, Physical Science, students in Grades K-4 develop an understanding of properties of objects and materials, position and motion of objects, and light, heat, electricity, and magnetism. In Grades 5-8, students develop an understanding of properties and changes of properties in matter, motions and forces, and transfer of energy (National Academy of Science, 1995).

Content Standard C focuses on Life Science. As a result of activities in Kindergarten through Grade 4, students develop an understanding of organisms; their characteristics, their life cycle; and their interactions with the environments. In Grades 5-8, activities develop an understanding of the structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms (National Academy of Science, 1995).

Content Standard D focuses on Earth and Space Science. Content for Kindergarten through Grade 4 includes properties of earth materials, objects in the sky and changes in earth and sky. Students in Grade 5-8 develop an understanding of the structure of the earth system, Earth's history, and Earth in the solar system (National Academy of Science, 1995).

Science and Technology is the focus of Content Standard E. Students in Kindergarten through Grade 8 develop abilities related to technological design and understandings about science and technology. In addition, students in Kindergarten through Grade 4 develop abilities to distinguish between natural objects and objects made by humans (National Academy of Science, 1995).

Understanding of Science in Personal and Social Perspectives are developed through activities identified in Content Standard F. Personal health is a component of all grades. In Grades K-4, students develop an understanding of characteristics and changes in populations, types of resources, change in environments, and science and technology in local challenges. In Grades 5-8, students develop an understanding of populations, resources, and environments, natural hazards, risks and benefits, and science and technology in society (National Academy of Science, 1995).

History and Nature of Science is the focus of Content Standard G. Science as a human endeavor is a common component of Kindergarten through Grade 8. Additionally, students in Grades 5-8 develop an understanding of the nature of science and the history of science (National Academy of Science, 1995).

In addition to process skills, such as observing, inferring, and experimenting, the Standards call for a focus on inquiry. Inquiry involves: (a) describing objects and events; (b) asking questions, (c) using critical and logical thinking to construct explanations, (d) testing explanations against current scientific knowledge; and (e) communicating ideas to others (National Academy of Science, 1995). According to Fisher (1998), the National Science Education Standards involve the scientific process of gathering data from observations and experiments, and using the knowledge gained to construct or demolish theories about how the

world works. It requires that students understand basic concepts, such as gravity and formation of compounds, while cultivating inquiry and investigation founded on children's natural curiosity.

Communication is an important component of the Standards. According to the National Academy of Sciences (1995), students need opportunities to present their abilities and understandings and to use the knowledge and language of science to communicate scientific explanations and ideas. Science education should include writing, labeling drawings, completing concept maps, developing spreadsheets, and designing computer graphics.

Texas Essential Knowledge and Skills for Mathematics (TEKS)

The Mathematics TEKS describe what students should know and be able to do at all grade levels and in all mathematics courses. When compared to the Essential Elements (Ees), the Mathematics TEKS provide more specificity and focus and address fewer topics in greater depth at each grade level. During Grades 4-8, students build a foundation of basic understandings in five areas: (a) Number, operation, and quantitative reasoning; (b) patterns, relationships, and algebraic thinking; (c) geometry and spatial reasoning; (d) measurement; and (e) probability and statistics. Problem solving, language, communication, connections, and reasoning underlie all content areas in mathematics.

Specific mathematical skills and processes are focused at each grade level. In Grade 4 the focus is on: (a) comparing and ordering fractions and decimals; (b) applying multiplication and division; and (c) developing ideas related to congruence and symmetry. The primary focus in Grade 5 mathematics is: (a) comparing and contrasting length, area, and volume of geometric shapes and solids; (b) representing and interpreting data in graphs, charts and tables; and (c) applying whole number operations in a variety of contexts. For Grade 6 the focus is on (a) using

ratios to describe proportional relationships involving number, geometry, measurement, and probability; (b) adding and subtracting decimals and fractions. Students in Grade 7 focus on: (a) using proportional relationships in number, geometry, measurement, and probability; (b) applying addition, subtraction, multiplication, and division of decimals, fractions, and integers; and (c) using statistical measures to describe data. Mathematics in Grade 8 focuses on (a) using basic principles of algebra to analyze and represent proportional and non-proportional relationships; and (b) using probability to describe data and make predictions. Students use these processes together with technology and other mathematical tools to develop conceptual understanding and solve problems as they do mathematics (TEA, 1998).

Texas Essential Knowledge and Skills For Science - TEKS

The Science TEKS describe what students need to know and be able to do at each grade level and in all subjects taught in Texas public schools. Compared to the EEs, the TEKS require fewer concepts and process skills so teachers have more time to develop them and students have more time to understand them. Skills and concepts are built from one grade level to the next in a coherent sequence. From Kindergarten through Grade 9, an integrated approach links physical, earth and space sciences, and life sciences. The TEKS divide science into knowledge (content) and process skills. In Grades 4 through 8, the focus is on science as a way of learning about the natural world. Built as a vast body of changing and increasing knowledge, science can be described by physical, mathematical, and conceptual models. At each grade level investigations and science skills are stressed.

The TEKS describe topics and delineate concepts that students should know and understand. For Grades 4-8 these include topics related to (a) systems; (b) matter and energy; (c) adaptations and inheritance; (d) past events; and (e) the natural world. Students are actively

involved in science process skills. In Grades 4-8 they (a) conduct field and laboratory investigations using scientific; (b) use critical thinking and scientific problem solving to make informed decisions; and (c) use a variety of methods and tools to collect, analyze and record information during science inquiry.

Throughout the TEKS an interdisciplinary approach is inferred. Science is linked to mathematics, technology, language arts and social studies. A blending of science and mathematics skills occurs. For example, students investigate transformations, use average, range, and frequency to analyze data, and construct graphs, tables, maps, and charts. Language arts are integrated into the TEKS. At all levels students draw and communicate through listening, reading, writing, and speaking skills. Science is integrated with social studies as students investigate the contributions and historical significance of science and scientists (TEA, 1998)

Middle School Reforms

Effective educational reform, geared exclusively for the middle school years, must be implemented to resolve the decline in academic achievement of students after leaving the elementary education years (Johnson, 1998). The greatest promise of school reform is a nation in which one cannot predict the relative academic achievement of children by examining variables such as socio-economic status, race, ethnicity, or language background. Johnson further stated that a nation in which all children have real opportunities to reap the benefits of its political and economic systems, whether their families live in suburbs or slums, gated communities or ghettos, mansions or homeless shelters is the true test of effective educational reform.

The National Middle School Association (NMSA, 1999) stated that exemplary middle schools addressed the distinctiveness of early adolescence with various instructional and

organization features. Educators, associations, foundations, state boards of education, and researchers generally recognize five key components. The first component, interdisciplinary teaming, described an organizational structure where a core of teachers are assigned to the same group of students. The second component, advisory programs, consisted of small group of students (usually 20 or fewer) assigned to a teacher, administrator, or other staff members for regularly scheduled meetings to discuss topics of concern to students. The third component, varied instruction, included integrating learning experiences, addressing students' own questions, and focusing on real life issues relevant to the student; actively engaging students in problem-solving and accommodating individual differences; emphasizing collaboration, cooperation, and community; seeking to develop good people, caring for others, democratic values, and moral sensitivity. The fourth component, exploratory programs, capitalized on the innate curiosity of young adolescents, exposing them to a range of academic, vocational, and recreational subjects for career options, community service, enrichment, and enjoyment. The fifth component, transition programs, focused on creating a smooth change of schools for the young adolescent. 88% of public school students begin the middle grades in a new school. The NMSA further stated that middle school reform must also have an emphasis on high content standards, high expectations, and high support.

Today, thoughtful schools and school systems are engaged in systemic changes whereby new curriculums, especially in mathematics and science, are a fundamental component of those changes. The array of quality, research-based curriculums is continuing to grow as scientists, mathematicians, and educators work together to study learning and improve the ways by which important ideas are learned (Lowery, 1998).

Brockett (1999) stated that current proposals in middle school reform have focused in several areas. Major areas of concern involved interdisciplinary teacher teams, curricular and instruction accommodations, commitment to standards, and staff development. Other areas of reform included multi-ability grouping, comprehensive school health programs, parent and community involvement.

Brockett (1999) described interdisciplinary teacher teams as the organization of teachers into teams who work with smaller clusters of the same students. Small communities of learning are created. Teams provide a structure for common teacher planning time, consistency of student-to-teacher and student-to-student relationships, and a sense of belonging that reduces isolation and anonymity, especially in large schools. It creates a positive psychological environment that allows flexibility, variety, and heterogeneous grouping of students. It provides a structure to plan and deliver a curriculum that balances academic and humane factors.

Brockett (1999) explained instructional accommodations as varying teaching styles to accommodate all students in mixed-ability groups. Instructional variations such as cooperative teaching and cooperative team learning with group individualized motivation strategies can boost substantially the effects of the regular education classroom. Varied instruction includes integrating learning experiences, addressing student's own questions and focusing upon real life issues relevant to the student. It actively engages the students in problem solving, accommodates individual differences, and emphasizes collaboration, cooperation, and community.

Every student should be able to meet high standards in mathematics, science, language arts, and social studies, by the end of eighth grade (Edna McConnell Clark Foundation, 1997). Current practices do not produce the results students need. Only principals and teachers can reform themselves and their schools in ways that will increase student achievement. The director

of the Edna McConnell Clark Foundation's Program for Student Achievement, Hayes Mizel, believes that Middle School reform requires the "courage to question long-standing assumptions; the determination to break away from negative attitudes and ineffective curricula and teaching methodologies; the humility to recognize that maybe someone else has knowledge and experience from which one can learn; and the resourcefulness to look both within and beyond the local school and the local school system for promising practices. It requires risk-taking. It requires putting the achievement of your student first and letting nothing stand in the way. It is the most difficult and important work imaginable," (cited in Edna McConnell Clark Foundation, 1997, p. 2).

Higher-order thinking skills have been identified as a reason why U.S. students have not progressed in comparison to international students (Pong, 1997). Middle-grade students are capable of developing higher order skills in both mathematics and science. In mathematics, these skills include abstracting more complex meanings and ideas from concrete experiences and using language to clarify thinking and report observations. In science, these skills include recognizing the relationship between explanation and evidence and using background knowledge to design investigations, make observations, and interpret data (Wheelock, 1996). "Project 2061: Science for All Americans" emphasizes thinking skills over specialized vocabulary and memorized procedures (Manning, 1998).

Cooperative learning is an important instructional technique for use with middle school students. Cooperative learning effectiveness is due to three components: simultaneous interaction, positive interdependence, and individual accountability (Colosi and Zales, 1998). According to the United States Congressional Office of Technology Assessment (1988), employees must be able to understand the complexities and technologies of

communication, ask questions, assimilate unfamiliar information and work cooperatively in teams (cited in NCTM, 1989, pg 3). Cooperative learning is consistent with National Science Standards which calls for teachers to "develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning" (National Research Council, 1996).

Interdisciplinary instruction involves deliberate to connect ideas and procedures between content areas through specific instructional activities. Mathematics and science instruction benefits from interdisciplinary. An integrated curriculum permits students to develop mathematical power more readily (NCTM, 1989; NCTM, 1999) and an interdisciplinary approach to teaching is encouraged by "Project 2061: Science for All Americans" (Manning, 1998). Rakow and Vasquez (1998) identified three approaches to integrated instruction: literature-based, theme-based, and project-based. In addition to the motivation value of literature, there is a strong skill crossover between reading and science. Both emphasize process skills such as observing, communicating, predicting outcomes, forming generalizations, and evaluating. Thematic instruction is a way for students to see how the disciplines are related. Project-based integration is an authentic form of cross-curricular integration because it involves students investigating real issues in real contexts.

In education, evaluations serve a variety of functions. They are used to: (1) make decisions about the content and methods of instruction; (2) make decisions about classroom climate; (3) help communicate what is important; and (4) assign grades. An evaluation program that is properly aligned with middle level reforms can not rely only on written tests that focus on right and wrong answers or specific, isolated skills. The evaluation provides information concerning students' understanding, insights, feelings and beliefs. The processes of science and

mathematics, as well as the content, must be evaluated. Calculators, computers, and manipulative must be included in the evaluation process. Professional development programs should include training in alternative assessment techniques such as observing and questioning students, analytic and holistic scoring, use of written responses in the form of short answer questionnaires, journal entries, and brief essays, performance assessment, and concept maps (Lester and Kroll, 19).

In order for a school to be effective in the implementation of educational reforms, the goals must be kept in sight at all times (Focused Reporting Project , 2000). According to the Edna McConnell Clark Foundation, the goal of reform is both simple and daunting. Every student should be able to meet high standards in mathematics, science, language arts, and social studies by the end of eighth grade. To reach this goal, educators and communities must first face the hard reality that current practices do not produce the results students need. Only principals and teachers can change these practices. Rather than focus obsessively on what they do not control, educators need to recognize what they do control and use the power they have to reform themselves and their schools in ways that will increase student achievement. Two key issues in educational reforms emerged (Focused Reporting Project , 2000, p. 2). Every student should meet high standards and faculty and administrative staff must admit that old practices are not working and should be abolished. The achievement of students must be first and nothing must stand in the way. Effective middle schools can be a reality with the incorporation of these reforms and the mentioned practices.

The creation of middle schools has often been motivated by research showing that young adolescents have distinct developmental needs, which in turn shape their educational needs and abilities. They are no longer dependent on the structures that characterize elementary education but they are also not yet ready for the independence of high school. Students between the ages

of 11 and 14 demand something different--something that recognizes and builds on their distinctive strengths (The Edna McConnell Clark Foundation, 1997). This is why educational reforms must be implemented. Reform is a process that takes time, but each year reform is delayed, many students are not adequately educated. They move from the sixth, to the seventh, to the eighth grades, and eventually into high school without the knowledge, direction, and self-confidence they need. Educators can help students create futures that are productive and fulfilling, but to do so reforms will have to be both deeper and wider than they have been to date. The clock is ticking for this and successive generations of students (Mizell, 1998). Implementation of educational reforms will ensure that the middle school child is not forgotten.

Teaching Practices

Educators have a consistent, predictable way of teaching mathematics in the United States and have used the same methods for nearly a century (Heibert, 1999). First, answers were given for the previous day's assignment. A brief explanation, sometimes none at all, was given of the new material, and problems were assigned for the next day. The remainder of the class was devoted to students working independently on the homework while the teacher moved about the room answering questions. The most noticeable thing about mathematics classes was the repetition of this routine. This same method of teaching persists, even in the face of pressures to change. Teachers are essentially teaching the same way they were taught in school. In the midst of current reforms, the average classroom shows little change.

Hiebert (1999) stated that most characteristic of traditional mathematics teaching is the emphasis on teaching procedures, especially computation procedures. Little attention is given to helping students develop conceptual ideas, or to connecting procedures they are learning with the concepts that show why the procedures work. A portion of the Third International Mathematics

and Science Study (TIMSS) involved videotape studies of actual U.S. classroom teachings (The Department of Education, 1998). In the lessons included in the TIMSS video study, procedures and ideas were only demonstrated or stated for 78% of the topics presented during the eighth-grade lessons. The procedures were neither explained nor developed. 96% of the time, students were completing seatwork assignments of procedures they had only been shown how to do. Heibert described traditional U.S. mathematics curriculum as repetitive, unfocused, and undemanding.

According to Fisher (1998), there is evidence that reform solutions in mathematics and science may already be occurring. Some U.S. eighth graders performed very well on the TIMSS test, but, strangely enough, they were not part of the official U.S. entry. They belonged to The First in the World Consortium, a three year-old coalition of 20 suburban Illinois school districts outside Chicago, with some 37,000 students. The Consortium arranged for its students to take part in TIMSS as if it were a foreign country. In mathematics, they ranked fifth, while the U.S. students counted in the study ranked 28th, last place. In science, the Consortium scored an impressive second, behind only Singapore, whereas the official U.S. finish was 18th. Unlike traditional mathematics curricula, they emphasize the development of children's reasoning abilities from the earliest grades, rather than concentrating on rote learning. Fisher further noted that the traditional approach, in which students tackle a new mathematical area each year and never return to an old one, is abandoned. Consortium students continue to revisit curriculum. Fisher recognized that one likely reason for the high scores is that half of the Consortium's students learned primarily through hands-on experiences not the rote memorization that is still common practice in most schools across the United States.

There are reforms specific to science and mathematics schooling that can be implemented across the economic and social spectrum. One is to improve the content and pacing of what is taught, or curriculum reform. The other is a better-trained teacher, both in the fields of expertise and in the methodology of how science and mathematics ought to be taught.

Hiebert (1999) ascertained that one of the most reliable findings from research on teaching and learning is students learn what they have an opportunity to learn. In most classrooms, students had more opportunities to learn simple calculation procedures, term, and definitions than to learn more complex procedures and why they work. They had fewer opportunities to engage in mathematical processes other than calculation and memorization. Data indicated that the traditional teaching approaches were deficient and could be improved. Hiebert further concluded that the evidence indicates that the traditional curriculum and instructional methods in the United States are not serving its students well. The long-running experiments that have been conducted with traditional methods show serious deficiencies, and careful attention should be given to the research findings that are accumulating regarding alternative programs.

The Department of Education (1998) stated that differences in national performance appear to be connected to what schools teach and how they teach it. What schools teach is delineated in standards, curricula, and textbooks. Most state curriculum frameworks in the United States demand breadth over depth, calling for many more topics and skills to be taught in a given year than other countries expect. Teachers respond to these demands by giving superficial coverage to as many topics as they can, seldom spending enough time on any one topic to allow students to achieve mastery.

The U.S. Department of Education (1998) stated that the findings of the TIMSS suggested directions for changes in U.S. curriculum policies. Curriculum reform means redefining content, grade by grade, to ensure coherent transitions from simple to more complex content and skills. It may also mean organizing topics in a different way. Merely emulating the curriculum practices of other countries is not an effective strategy for the United States.

According to the U.S. Department of Education (1998), U.S. teachers usually teach a mathematics lesson by explaining a topic and demonstrating a procedure. Then the students practice solving problems while the teacher goes around the room helping those who are having trouble. In other countries, students spend less time practicing routine procedures and more time analyzing and proving. Students focus on just one or two carefully selected problems, and form a complete story with a beginning, middle, and end. Students work on a challenging problem for part of the class period, then share their solutions. After allowing students time to struggle with challenging problems, teachers in other countries often follow up with direct explanations and summaries of what students have learned.

Another gauge of quality teaching is whether key mathematical concepts and procedures are developed through examples, demonstrations, and discussions, or whether they are simply stated by the teacher (U.S. Department of Education, 1998). For example, one teacher might state that the area of a right triangle is calculated by following a specific formula (1/2 base x height); another might develop this procedure by showing how the formula can be derived by combing two triangles to form a rectangle. In German and Japanese lessons, mathematics concepts and procedures were generally well developed; in U.S. lessons, these concepts were usually just stated and not developed.

The Department of Education (1998) stated that mathematics teachers have changed some aspects of their teaching in response to the NCTM professional standards, such as using real-world problems, manipulatives, or cooperative learning, but they apparently have not changed the more fundamental scripts from which they work. The real challenge is to develop standards that are concrete enough to be useful to teachers, to identify a limited number of topics to be taught at each grade, and to provide advice on how to teach them. Accountability is another critical element of standards-based reform.

The Department of Education (1998) stated that U.S. teachers usually concentrate on having the students learn how to do something. Teachers focus on how to use the Pythagorean theorem to find the length of the third side of a triangle when the lengths of two are known. They neglect teaching the students to understand why the square of the third side of a triangle equals the sum of the squares of the other two sides. Memorization, rather than understanding and application, is taught. The TIMSS videotape study also found that U.S. teachers usually stated concepts rather than allowing students to develop the concepts themselves.

The quality and composition of textbooks is a major concern in mathematics and science education and reform. Textbook sequence and content determines the curriculum too often. Traditional textbooks are not aligned with the national standards. In mathematics textbooks (Grades K-8), the primary focus is on arithmetic and topics are repeated at the same level of presentation grade after grade. New material is left for the end. Texts in grades K-8 often include a variety of mathematical topics but primarily stress arithmetic (NCTM, 1989; Wheelock, 1995). Traditional textbooks often impede progress toward science literacy. They emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understandings in context, recitation over

argument, and reading in lieu of doing. They fail to encourage students to work together, to share ideas and information freely with each other, or to use modern instruments to extend their intellectual capabilities (American Association for the Advancement of Science, 1996).

Schools do not need to teach more content. Schools need to teach less and teach better in order to improve student achievement (American Association for the Advancement of Science, 1996). The AAAS stated that the typical U.S. textbook covers more topics in less depth than other international textbooks resulting in an "overstuffed and undernourished" curriculum. A German science text typically covers about 9 topics and Japanese texts between 8 and 17 topics. A typical U.S. science text covers between 53 and 67 topics, depending on the grade level. The five most emphasized topics in the U.S. 4th grade science texts accounted for 25% of the total textbook space compared to the international average of 70 to 75%. The five most emphasized topics in U.S. General Science texts (8th grade) accounted for 50% of the textbook space compared to 60% internationally (National Research Council, 1996). Standards can not be met simply by altering current texts. Other materials that support the standards, such as manipulatives and courseware, must also be developed (NCTM, 1989).

Schoen and et al (1999) stated that as mathematical curricular traditions have been reconsidered over the past decade, several major changes need to be in order. First, the emergence of powerful technologies for numeric and graphic mathematical calculation suggested changes in the traditional focus of school curricula on procedural skills in arithmetic and algebra. It seems more feasible to reduce the time devoted to training students in paper-and-pencil operations that can now be executed rapidly and accurately with low-cost calculators and computers. The integration of technology into the classroom is an integral component of national mathematics standards. Technology helps students explore, experiment, verify and visualize

mathematical ideas. The National Council for Teachers of Mathematics (1999) recommended that a computer for demonstration purposes should be in every classroom. Students need computer access for individual and group work. Appropriate calculators should be available to all students at all times. Students need the use of the computer as a tool for processing information and performing calculations to investigate and solve problems. Students need experiences with spreadsheets, graphing, and dynamic geometry software. Students should have use of Internet search techniques to gather information and solve mathematical problems.

Surveys of computer and calculator availability show that few classrooms are in alignment with national standards. In 4th grade classrooms, 35% had one computer is available for mathematics and science instruction, 29% have two or more computers while 6% have no computers. Computers were never used in 38% of elementary science lessons and 44% of lessons in grades 5-8 (Weiss, 1994; National Research Council, 1996). Only 20% of 8th graders had computers in

their classrooms (Wheelock, 1995). 19% of 8th graders were permitted free use of calculators while 34% were permitted to use calculators when taking tests. Teachers reported that 22% of 8th graders were never asked to use a calculator in class. Implemented correctly, the standards do not abandon learning mathematics facts, such as addition and multiplication (Fisher, 1998).

Schoen and et al (1999) stated that as mathematical curricular traditions have been reconsidered, not only must technology use be addressed but, secondly, topics in probability, statistics, and new areas of discrete mathematics deserve more substantial treatment than traditional curriculum has provided. Third, it may be more appropriate to present mathematical topics through integrated curriculum that develops all major content strands in each year of secondary school, rather than in separate yearlong courses. Fourth, most students would learn

better from a curriculum that develops key ideas from work on concrete problems in meaningful real-life contexts. This emphasis on learning through problem solving is consistent with widespread concern that students should acquire the ability to apply mathematical ideas and techniques to problem solving and decision making in other fields of work. Finally, students need to have well-developed abilities to analyze problem situations and to communicate ideas for solving those problems. Thus the mathematics curriculum should focus on broad reasoning and communication goals as well as on specific content topics.

Schoen and et al (1999) stated that the typical classroom and standardized tests of student achievement have emphasized short-answer questions and computational exercises in formats that can be scored quickly and objectively. Reflecting insights from international comparisons and the desire to focus testing on conceptual understanding and problem solving, the authors of the NCTM Standards documents proposed significant changes in the practice of assessment and evaluation. The main themes in the assessment proposals from NCTM included using a variety of assessment tools, from classroom observation and journal writing to extend projects, portfolios, open-ended problems, and conventional tests. Teachers need to improve the alignment of assessment practices with curricular goals and embed assessment in everyday instructional activities so that it contributes to the improvement of teaching, not merely to the assignment of grades.

The Core-Plus Mathematics Project (CPMP) is one of several National Science Foundation-supported efforts to design, prepare, evaluate, and disseminate curricular options for a standards-based high school mathematics program (Schoen and et al, 1999). Schoen and et al stated that CPMP students agreed (79.2%) that cooperative group work helped them learn mathematics. The advantages of learning in groups most often cited by the students were seeing

how other people attacked problems and the support of group members during problem-solving efforts. A significantly higher percentage of CPMP students than traditional students agreed that their mathematics course contained realistic problems, making the mathematical ideas interesting, and increasing their ability to talk and write about mathematics. The levels of agreement for CPMP students on these survey items ranged from 66.5% to 76.5% compared with 40.6% to 47.8% for traditional students. CPMP students were much more likely than traditional geometry students (75% versus 42%) to want to take a mathematics course taught in the same way in the coming year. These findings, coupled with substantial increases in enrollments in junior and senior mathematics courses in many field test schools, provided strong evidence that the CPMP curriculum was a factor in keeping more students in mathematics courses longer.

Hiebert (1999) discovered significant similarities of effective mathematics and science alternative programs. Arithmetic teaching included the following. First, the teaching built directly on students' entry knowledge and skills. Many students enter school being able to count and solve simple arithmetic problems. Alternative programs took advantage of this ability by gradually increasing the range of problem types and the sizes of the numbers. Second, opportunities for both invention and practice were provided. Classroom activity often revolved around solving problems that required some creative work by the students and practice of previously learned skills. For example, second graders may have been subtracting numbers like 345 – 127 and then were asked to work out their own methods for subtracting 403 –2 65 (a problem with a 0 in the subtrahend). Third, focus was placed on the analysis of (multiple) methods. Classroom discussion usually centered on the methods for solving problems, methods that had been presented by the students or the teacher. Methods were compared for similarities and differences, advantages and disadvantages. Fourth, teachers would ask students to provide

explanations. Students were expected to present solutions to problems, to describe the methods they used, and to explain why methods worked.

Hiebert (1999) noted similar teaching practices between mostly elementary school students' learning of arithmetic, and teaching methods in secondary alternative programs. First, instructional programs emphasized conceptual development, with the goal of developing students' understanding. This facilitates significant mathematical learning without sacrificing skill proficiency. Instruction could be designed to promote deeper conceptual understanding. Hiebert stated that if students have more opportunity to construct mathematical understandings, they would construct them more often and more deeply. Results show that well-designed and implemented instructional programs can facilitate both conceptual understanding and procedural skills. Second, students learned new concepts and skills while they solved problems. The traditional approach has been for teachers to demonstrate a mathematical procedure and then for students to solve problems by practicing that specific procedure. Problem solving was viewed as an application of the learned procedure. The alternative instructional programs took a different approach. The theory on which these programs were based stated that students could acquire skills while they developed them to solve problems. In fact, the development of the skill, itself, can be treated as a problem for students to solve. Third, if students over-practiced procedures before they understood them, they had more difficulty making sense of them later. A long-running debate has been whether students should practice procedures first and then try to understand them or should they understand the procedures before practicing them. Hiebert concluded that the best evidence suggests that if students have memorized procedures and practiced them, it is difficult for them to go back and understand them later.

Fisher (1998) stated that the National Council of Teachers of Mathematics (NCTM) emphasized that traditional curricula are not only too narrow, but children begin to loose their belief that mathematics is a sensemaking experience (p. 94). Few current teachers have been exposed to the latest findings about how children actually learn mathematics and science. Fisher discussed these latest findings, from the discipline called Cognitive Science, and suggested that the traditional teaching method, in which the teacher transmitted information to the student who is then expected to memorize it and regurgitate it on command, is less effective than the so-called constructivist technique. The constructivist approach encourages explorations, with guidelines set out by the teacher. Students are not supposed to "invent" mathematics on their own, as some critics worry, but are expected to struggle with problems before coming to the answers. The notion holds that students will learn mathematics better if they are left to discover the rules and methods of mathematics for themselves, rather than being taught by teachers or textbooks. Teachers must become extremely skilled in these methods, and if children sometimes discover the wrong rules, the teacher must correct the error.

Lowery (1998) stated that a new view of learning draws its strength from cognitive neuroscience, cognitive psychology, and artificial intelligence. The new view can be expressed through three component statements: learners construct understanding for themselves; to understand is to know relationships; and knowing relationships depends on having prior knowledge. Lowery continued to explain that the brain stores a record of the neural activity that takes place in the learners' sensory and motor systems as they interact with the environment. The traditional show-and-tell teaching methods, such as lectures, demonstrations, and textbook narratives, activate only a few of the many possible avenues to the brain. The National Science Foundation has been funding multisensory laboratory-oriented science and mathematics projects.

These projects included Full Option Science System, Science Education for Public Understanding Program, Lawrence Hall of Science; Science and Technology for Children, National Science Resources Center, Insights, Education Development Center; and Mathematics in Context. The enriched environments that these projects have developed involve learners in a variety of inquires within powerful content contexts, thus increasing the likelihood that students will construct worthwhile knowledge and thinking capabilities.

Lowery (1998) further noted that although the individual constructs basic knowledge through experience, the quality of the construction depends on how well the brain organizes and stores the relationships between and among aspects in the event. Learners try to link new perceptions to what they have already constructed in the brain's storage systems. They use this prior knowledge to interpret the new material in terms of established knowledge. Whenever bits of information are isolated from these systems, they are forgotten and they become inaccessible to memory. Because students can explore, manipulate, test, and make transformations in the objects at hand, enriched environments and quality, hands-on experiences contribute significantly to piquing students' interests and linking their perceptions stored with the brain. Written formats, such as textbooks, give minimal help because symbols are not reality. They cannot be acted on or manipulated. If readers have little memory related to the content of what they read, they will gain little from reading. Because reading has such power when it follows experience, the recently developed National Science Foundation-sponsored elementary science programs provide reading materials after the students have gained some experience. The new curriculums provide good examples of how to enable learners to construct their own ideas through an exploration of relationships among materials (objects and ideas) and through the use of the reinforcement of prior knowledge. Each new challenge does two things: provides a replay

of prior knowledge constructions, thus making them more permanent, and provides something new that the brain can assimilate into its prior constructions, thus enriching and extending those constructions.

Science teaching standards are delineated in Chapter 3 of the National Science Education Standards (National Academy of Science, 1995). These standards are based on five assumptions: (1) the vision of science education described by the Standards requires changes throughout the entire system; (2) what students learn is greatly influenced by how they are taught; (3) the actions of teacher are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned; (4) student understanding is actively constructed through individual and social processes; and (5) actions of teachers are deeply influenced by their understanding of and relationships with students.

According to the Standards, teachers of science should: (1) plan an inquiry-based science program for their students (Standard A); (2) guide and facilitate learning (Standard B); (3) engage in ongoing assessment of their teaching and of student learning (Standard C); (4) design and manage learning environments that provide students with the time, space, and resources needed for learning science (Standard D); develop communities of science learners that reflect the intellectual rigor of scientific inquiry and attitudes and social values conducive to science learning; and, (5) participate in the ongoing planning and development of the school science program (national Academy of Science, 1995).

Schools need to focus on the following changes: (1) less emphasis on treating all students alike and responding to the group as a whole; (2) rigidly following curriculum focusing on student acquisition of information; (3) presenting scientific knowledge through lecture, text, and demonstration; (4) asking for recitation of acquired knowledge; (5) testing students for factual

information at the end of the unit or chapter; (6) maintain responsibility and authority; and, (7) supporting competition and working alone (National Academy of Science, 1995). The Standards places more emphasis on: (1) understanding and responding to individual student's interests, strengths, experiences, and needs; (2) selecting and adapting curriculum; (3) focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes; (4) guiding students in active and extended scientific inquiry; (5) providing opportunities for scientific discussion and debate among students; (6) continuously assessing student understanding; (7) sharing responsibility for learning with students; (8) supporting a classroom community with cooperation, shared responsibility, and respect; and working with other teachers to enhance the science program (AAAS, 1996).

The National Academy of Sciences (1995) stated that teachers of science for middle-school students should note that students tend to center on evidence that confirms their current beliefs and concepts (i.e. personal explanations), and ignore or fail to perceive evidence that does not agree with their current concepts. It is important for teachers of science to challenge current beliefs and concepts and provide scientific explanations as alternatives.

The National Academy of Sciences (1995) further stated that several factors of the national Standard A, Science as Inquiry, should be highlighted. The instructional activities of a scientific inquiry should engage students in identifying and shaping an understanding of the question under inquiry. Students should know what the question is asking, what background knowledge is being used to frame the question, and what they will have to do to answer the question. The students' questions should be relevant and meaningful for them. To help focus investigations, students should frame questions, such as "What do we want to find out about…?"

How can we make the most accurate observations?", "Is this the best way to answer our question?" and "If we do this, then what do we expect will happen?"

The National Academy of Sciences (1995) summarized that in most middle schools, students produce oral or written reports that present the results of their science inquiries. Such reports and discussions should be a frequent occurrence in science programs. Students' discussions should center on how to organize the data to present the clearest answer to a question. Focus should also be given to what evidence would be used to present the strongest explanation. Out of the discussions about the range of ideas, the background knowledge claims, and the data, the opportunity arises for learners to shape their experiences about the practice of science and the rules of scientific thinking and knowing.

The National Academy of Sciences (1995) stated that suitable design tasks for students at these grades should be well-defined, so that the purposes of the tasks are not confusing. Tasks should be based on contexts that are immediately familiar in the homes, school, and immediate community of the students. The activities should be straightforward with only a few well-defined ways to solve the problems involved. The criteria for success and the constraints for design should be limited. Only one or two science ideas should be involved in any particular task. Any construction involved should be readily accomplished by the students and should not involve lengthy learning of new physical skills or time-consuming preparation and assembly operations.

The National Science Education Standards recommends that "it is important for students to learn how to access scientific information from books, periodicals, videos, databases, electronic communication, and people with expert knowledge," (National Research Council, 1996, p. 44). Whitworth (1997) noted that reform is difficult and subject to constraints from a

variety of levels. Suggestions that facilitate the successful implementation of school reform include increased teacher planning time, technology development, better student assessment techniques, and provisions to ensure continuity of the program.

Eggebrecht, Dagenais, Dosch, and Merczak (1996) supported an integrated science program. Integration provides engaging experiences in which students encounter essential content in multiple and meaningful contexts in response to their own inquiry. If learning has value, Eggebrecht et al stated that students should be able to transfer the knowledge they acquire in school to the world beyond the classroom. In integration, the expert does not create or convey meaning to the novice. The student must take ownership of his or her own learning, and remove any barriers to inquiry. When the student directs his or her own learning, the learning is often not neatly compartmentalized within the scientific disciplines. Integration focuses on the concrete by introducing the idea of a problem platform, a physical, project-based context to support the curriculum. Integration establishes a means of creating a learner-centered institution, where both adults and children pursue useful knowledge.

Standards by themselves cannot work the magic of school reform. They only set the stage for both harder and smarter work among professionals who want to improve teaching and learning (Wheelock, 1996). In order to implement reforms effectively, it is necessary to initiate a comprehensive change in all components of the educational process. This is referred to as systemic reform. Systemic reform requires determination, resources, leadership and time (American Association for the Advancement of Science, 1996). Systemic change is more successful in individual schools than whole districts. There must be "top-down" (administrative) support for "bottom-up" (teacher directed) reforms in teaching, curriculum, assessment, and professional development (Wheelock, 1995). Schools that adopt a systemic approach to reform

are more likely to focus on changes in classroom practices and keep attention on changing these practices than schools that simply mobilize extra materials and resources to meet specific student needs. Schools with systemic approaches to change are twice as hospitable to pedagogy that emphasizes in-depth knowledge, conversations about learning, and projects connected to the world beyond school. 64% of the systemic change schools reported moderate or extensive use of such learning practices, compared to 31% of schools with an unfocused approached (Wheelock, 1996).

In order to effectively lead and implement reform, teachers must be given support, time and resources. In order to implement change, the National Reading Council (NRC, 1996) and NCTM (1989; 1999) have identified common barriers that teachers face when attempting to implement change. These barriers include: (1) administrative directives about which chapters or pages to cover; (2) inadequate time for instruction, planning and preparation; (3) preparation for and administration of tests; (4) too little time is spent on mathematics instruction; (5) lack of equipment, supplies, manipulatives, technology, and physical resources; (6) few opportunities to share ideas with other teachers and reflect on teaching practices; (7) difficulty in creating a sense of exploration curiosity, or excitement in the classroom; (8) the political framework within which the school operates; and (9) attitudes, expectations and strongly held beliefs by educators and the community.

Lowery (1998) believed that flexible abstract reasoning is used extensively in curriculum reform. The fundamental strategy of curriculum reform rests in the method in which developmentally appropriate concepts are sequenced, progressively linked, and webbed together toward an interdisciplinary theme or generalization. Without such a strategy, the curriculum is a pseudocurriculum, an eclectic collection of activities with weak, if any, linkages and no long-

range goals or purpose. Lowery believed that the underlying sequential strategy gives the curriculum reform its integrity. The sequence of the learning transformations is important, not the grade levels of ages of acquisition. The curriculum reform's intent is to make what the student is capable of learning more useful, effective, relevant, and interesting. It also aims to enable the student to progressively build, from grade level to grade level, an understanding of the interdisciplinary theme or generalization of a subject by relating subsequent knowledge to prior knowledge. With so much explicit knowledge about how the brain works and with data so clearly supportive of the fact that students construct knowledge for themselves, it is surprising that so little real change has occurred in the way that science and mathematics are taught.

Hiebert (1999), when concluding, stated that when considering what can be learned from research about the effects of different instructional approaches, educators must continue calibrating expectations. After all, research is not filled just with limitations; it holds enormous potential.

Professional Development

The purpose of this section of the literature review was to identify components of successful professional development programs that focus on middle level mathematics and science teachers. The review of literature indicated that professional development is critical to the overall success of any educational program. The teacher is the key individual who must translate the vision into action. Without effective training, teachers may lack the skills necessary to communicate with students and to develop a curriculum that meets the needs of diverse groups of learners. This review addressed the key aspects of effective professional development programs in general and narrowed the focus to address specific needs of mathematics and science teachers at the middle school grades.

In virtually every state in the country, reform efforts are dramatically raising expectations for students, and consequently, for teachers. In response to these reform initiatives, educators are being asked to assume new skills and responsibilities and to change practices. Corcoran (1995) noted that in order to meet these new expectations, teachers needed to deepen their content knowledge and learn new methods of teaching. They needed more time to work with colleagues, to critically examine new standards, and to revise curriculum. Teachers needed opportunities to develop, master and reflect on new approaches to working with children. All of these activities fell under the general heading of professional development.

The United States Department of Education (1995) outlined the components of quality professional development that included the following recommendations. Professional development:

- focuses on teachers as central to student learning, yet includes all other members of the school community
- focuses on individual, collegial, and organizational improvement
- respects and nurtures the intellectual and leadership capacity of teachers, principals, and others in the school community
- reflects best available research and practice in teaching learning and leadership
- enables teachers to develop further expertise in subject content, teaching strategies, use of technologies, and other essential elements in teaching to high standards
- promotes continuous inquiry and improvement embedded in the daily life of schools
- is planned collaboratively by those who will participate in and facilitate that development
- requires substantial time and resources
- is driven by a coherent long-term plan

- is evaluated ultimately on the basis of its impact on teacher effectiveness and student learning; and this assessment guides subsequent professional development efforts.

Another framework for effective professional development, according to the National Staff Development Council, was designed to address the three critical components of professional development: context, process, and content. Context addressed the organization, system, or culture in which the new learning would be implemented. It refers to the "who", "when", "where", and "why" of professional development. Process refers to the "how" of professional development; it describes the means for acquisition of new knowledge and skills. Some examples of process standards include group development, follow-up and support, and evaluation. Content refers to the actual skills and knowledge effective school administrators need to possess or acquire through professional development. Examples of content include research-based instructional strategies, pre-adolescent and adolescent development, high expectations, and curriculum.

Effective professional development is a critical factor when implementing an instructional program. The Middle Grades Initiative National Advisory Panel reviewed over 450 instructional programs and identified characteristics of effective professional development activities. The professional development program was well organized. It clearly identified what participants should know and should be able to do as a result of taking part in the program. It demonstrated how learning experiences needed to be structured. The program provided for ongoing support as teachers changed their behavior to integrate new learning into their classroom practice. Content-specific professional development for middle school teachers designed to improve teachers' content knowledge and/or content specific pedagogical skills in the core content areas was included.

Professional development activities must engage teachers in concrete tasks of teaching, assessment, observation, and reflection that illuminate the processes of learning and development. It must be grounded in inquiry, reflection, and experimentation that are participant-driven. Professional development must be collaborative, involving a sharing of knowledge among educators and a focus on teachers' communities of practice rather than on individual teachers. It must be connected to and derived from teachers' work with their students. Professional development must be sustained, ongoing, intensive, and supported by modeling, coaching, and the collective solving of specific problems of practice. It must be connected to other aspects of school change.

In a study on the effective components of staff development, Zemelmen, Daniels, and Hyde (1994) found that regardless of subject area or curriculum, six key ingredients are needed for effective professional development programs. First, teachers need time together to talk, encourage, compare ideas, trouble-shoot when things don't go as expected, and organize cooperation between classrooms. Achieving real instructional change requires more than brief sessions of instruction for teachers once or twice a year. Deep inquiry into mathematics or science requires time to build group trust, experience model activities, discuss, disagree, re-think, and work out classroom applications.

Second, because teaching involves so much daily isolation from fellow professionals, it is important that teacher make conscious efforts to have collaborative, social experiences. Collaborative work among teachers on tasks that have concrete results in classrooms builds supportive bonds.

Third, teachers need to know that the administration is supportive of new initiatives. Teachers need to know where their principal stands. The best professional development effort in

the world will fail if school leaders do not consistently support the changes. This need for administrative support is especially strong in urban schools, where chaotic conditions make it extra difficult for a teacher to carry out classroom changes. A strong, encouraging principal, who knows curriculum, welcomes innovation, and believes in teachers, and who does not him/herself impose sudden arbitrary requirements, is vital.

Fourth, teachers need to be supported and strengthened as professionals if they are to assume more decision-making roles. Teaching practices must be viewed as strategies to be compared, analyzed, and then adapted to one's own style. The school staff must be viewed as more of a community. Improvement is necessary because in teaching, there is always more to learn.

Fifth, professional development programs using concrete experiential activities, rather than starting with educational philosophy or research data most effectively initiate the strengthening of professional commitment and the introduction of new classroom strategies. Experts in every curriculum field have found that children's learning must be experiential and authentic, reflective and constructivist. Teachers have as much need for these ingredients as their students do. Powerful experiential activities are not merely "demonstrations;" they immerse participants in fresh alternatives instead of just initiating debate about them. Teachers need to directly experience models of what is possible in the classroom, to end the isolation which cuts them off from alternatives, and work out the many details that go into a new classroom approach.

Finally, after experiencing new classroom strategies, teachers need to reflect, to analyse, and to compare -- to build knowledge and theoretical understanding. Teachers need experiential activity first, as an inductive approach to theory.

Teaching is a difficult task and has become more complex as teachers are required to assume various roles outside of the basic transference of intellectual concepts. In order to address those changing needs, professional development programs must adapt to meet the emerging needs of teachers. According to Corcoran (1995), the educational community will move away from past models of professional development to new models that embed professional development into the daily lives of teachers. The educational community will restructure teachers' work to create the mental space necessary for ongoing professional development. The community will assess how current professional development resources are being used and design strategies for securing additional resources as needed for reallocating them. The educational community will develop strategies for informing and convincing the public and policymakers that professional development not only is critical but also is as much a part of teachers' work as is instruction.

Professional development is a component addressed in national standards. The change strategy of the standards is based on teacher empowerment rather than administrative directives. Through professional development, teachers are empowered to make changes (NCTM 1989, 1999). Most teachers have relatively few opportunities to learn new methods of teaching (Hiebert, 1999). Science teachers polled by the NSTA emphasized a need for meaningful professional development to fully implement the science standards (Wheelock, 1996).

It is important that the leaders of the professional development sessions model the instructional methods and strategies that are outlined in the standards. The standards require a change in instructional methods that must be acquired through experiences. Unless teachers "experience" reformed science teaching, it is unrealistic to expect change. In order for teachers to model effective practices of teaching and learning as outlined by the national reform

initiatives, they must participate in activities that cause reflection and apply the standards to lessons that they can or will use (Hammrich, 1997). Professional development programs must link teacher training and classroom practices. Teachers must be actively involved in scientific processes, exploring, conjecturing, communicating, and reasoning (NCTM, 1989).

Cooperative learning should be a component of a professional development program. Research suggests that teachers are unfamiliar with the fundamental premise of cooperative groups. A common concern is the difficulty inherent in establishing individual accountability of all students in a cooperative group setting. (Roychoudhury and Kahle, 1999).

Professional development programs should include components that focus on pedagogical practices, what students think about mathematics and science. Teachers must be familiar with the pedagogical philosophy addressed in the standards that reflects current research in science education. Just telling teachers what pedagogical changes are desired is unlikely to have any effect (Hammrich, 1997). It is critical for teachers to develop expertise through a thorough understanding both of mathematical content and of student's mathematical thinking. Teachers need to be familiar with research on how students learn mathematics (NCTM, 1999).

National and state standards should be addressed during professional development programs. During professional development activities, teachers need to learn to apply the principles of the national reform initiatives in designing, implementing, and evaluating curriculum, instruction, and assessment. Teachers need the opportunity to work with the standards either through analysis of existing curricula or development of their own lessons and curriculum. Only in doing so will teachers gain a new and better understanding of science and effective science instruction (Hammrich, 1997).

There is an ongoing need for professional development in the area of content for middle level teachers. Few elementary school teachers have even a rudimentary education in science and mathematics. Many secondary teachers of science and mathematics do not meet reasonable standards of preparation in those fields. (Edna McConnell Clark Foundation, 1997). Extensive professional development in content knowledge contributes to positive changes in teaching and learning of science. (Roychoudhury and Kahle, 1999). According to Weiss (1994), only 71% of middle school science teachers have a degree in science. Of the approximately 1.9 million elementary teachers nation-wide, the vast majority earned degrees in education rather than in specific science disciplinary areas (Weiss, 1994).

As educators develop curricula and create and select instructional materials, it is essential that the materials selected reflect the "higher" cognitive parameters of the standards. Through professional development activities, educators need to learn how to critically analyze materials to assess alignment with the standards. This is a skill that must be taught, focused, and practiced (Wheelock, 1996). Lewis (1996a) suggested three general questions that needed to be asked when evaluating materials. First, how good are the materials at encouraging teachers to teach differently? Second, do the instructional materials provide students the opportunity to make conjectures, gather evidence, and develop arguments to support, reject, and revise their explanations for natural phenomena? And finally, do the materials develop connections between science and mathematics?

Participation in professional development alone will not ensure that new strategies or reform initiatives are effectively implemented. The literature review has identified time as a barrier to the effective implementation of an instructional program. When evaluating the implementation of mathematics projects, weak implementation was found to be a result of staff

not having time to learn new practices (Hiebert, 1999). Even for teachers committed to change, altering their usual mode of teaching requires time, typically several cycles of trial and error accompanied by careful observations and analyses of goals and practices (Roychoudhury and Kahle, 1999). Hammrich (1997) evaluated teacher education students' conceptions of science, teaching and learning in a science methods course that utilized principles derived from National Science reform initiatives. Although the students recognized the necessity of aligning curriculum to match the content and pedagogy implied by the national reform initiative, they felt that the time need to conduct such a process might out weight the benefits. The students acknowledged that they gained an overwhelming amount of experience and knowledge from learning about, planning, and applying the principles reflected in the national reform initiatives. They were also frustrated by the time commitment necessary to actually plan and apply the standards.

Collaboration, communication, and administrative support are vital components of effective professional development programs. The purpose of collaboration in a professional development program is to improve practices among teachers, to develop coherence to local school improvement plans and to create a center for the development of knowledge for the teaching profession (Clark, Glesne,and Kostinet, 1998). It is more effective to have a group of teachers attend professional development together rather than one teacher per school or grade level. The power of innovation is diluted when it is grounded in individual practices rather than in concerted efforts. Schools should take a team approach to reforming science teaching (Roychoudhury and Kahle, 1999). Communication should be a component of professional development programs. Teachers should talk about teaching practices, professional experiences, and interpretations and applications of the standards. Given (1999) reported that adult learners

retained only 20% of what they heard but 70% of what they said. Adults can increase their memory retention to 90% by talking about the personal significance of what was presented. The role of the principal as a leader, capable of bringing teachers together, is necessary to change both school culture and teaching practice (Roychoudhury and Kahle, 1999).

The literature review identified key components that effective professional development programs must possess. Effective programs are developed in collaboration with teachers, provide for sustained collegial interaction, link professional development and classroom practices, and have administrative support for proposed changes. Professional development is critical to the success of all educational programs because it serves as the link that connects vision and philosophy with action.

Chapter III

Procedures

Introduction

This chapter addresses procedures used to acquire data to assess mathematics and science education in South Texas schools. Addressed will be the research design, the sample, the survey instrument, data collection, and data analysis.

Research Design

A survey research design was used to collect descriptive and qualitative data. A cross-sectional survey was used to collect information from the sample population during one time period. This type of survey is useful when the sample population is dispersed over a large geographical area. Tentative conclusions, reflecting current experiences and practices, can be drawn from this type of survey. Teaching methodologies or experiences occurring earlier than the previous year are not specifically reflected in the responses and their impact may or may not be reflected in responses. A weakness of a survey research design is that different conclusions may be drawn from future research studies due to changes in school organization, teaching assignments, instructional methodologies, and professional development activities that occur after completion of the survey.

Sample

The target population was all Grades 4 through 8 mathematics and science teachers in the state of Texas. The accessible population was Grade 4 through 8 mathematics and science teachers in Education Service Center (ESC) regions 1, 2, 3 and 20. A stratified random sample was used to focus on teachers of students in Grade 4 through 8. A list of schools containing one of more of the targeted grades was obtained from the Texas Education Agency (TEA). A table of

random numbers was used to select 25 schools from each region. Based on school population data provided by TEA, the 100 targeted schools would yield a sample population of approximately 350 mathematics and/or science teachers in Grades 4 through 8. The validity of the sample population was dependent upon the principal distributing the survey to teachers who taught mathematics and/or science in the selected grades.

Instrument

The purpose of the instrument was to collect data concerning the current status of mathematics and science education in South Texas and the perceived needs of the teachers. Standardized instruments failed to meet the specific needs of this study and were rejected despite the advantage of saving time. Data collection was completed using A survey developed by the authors was used to collect the data for the study (see Appendix A). The instrument was field tested by 5th and 6th grade teachers in order to verify readability and to assess the validity of the instrument. The instrument contained 30 questions requiring a variety of response methods. Depending upon the question, teachers responded by checking an item, filling in response circles to indicate choices, or writing a short response to a question. For some questions, the response choices were "very well," "somewhat well," "not at all well," and "does not apply." For other questions, teachers responded to questions by selecting items from a given list. In addition to demographic data (subject and grade taught), teachers were asked to respond to questions in four areas: curriculum standards, instructional methodologies, resources, and professional development.

Curriculum Standards

In the area of curriculum standards, teachers were asked to rate their (1) knowledge and implementation of national and state curriculum standards, (2) input during curriculum

implementation, (3) ability to develop an integrated mathematics/science lesson, (4) ability to conduct a scientific investigation, and (5) knowledge of content taught.

Instructional Methodologies

Teachers were instructed to indicate the frequency of specific instructional methodologies used each week. Areas that prevent teachers from implementing a more effective instructional program were identified. Teachers also identified instructional methodologies utilized the most, utilized the least, and those perceived as most effective. Teachers were asked to indicate daily availability of calculators, computers, and mathematic manipulates.

Professional Development

Teachers were asked to indicate the number of subject-related professional development hours they participated in during the past year. They were also asked to identify professional development areas in which they had the most experience, the least experience, and those they perceived to be most beneficial in improving and updating teaching effectiveness. Interest in the future Mathematics and Science Middle School and related professional development activities were assessed.

Data Collection

During March, 2000, surveys were mailed to the targeted schools along with a letter requesting the principal's aid in distributing, collecting, and returning the completed surveys to the Texas A&M Research Center by April 1, 2000. The principals were instructed to distribute surveys to mathematics and/or science teachers in Grades 4, 5, 6, 7, or 8. To facilitate a response, a stamped addressed return envelope was included in the original mailing. An acceptable response rate of 50% was identified. After April 1st, attempts were made to contact schools that had not returned surveys in order to achieve the acceptable response rate. Analysis of data was

restricted to surveys received by April 19th, 2000. Fifty-six percent (56%) of the targeted schools returned surveys resulting in a survey response rate of 51% (177 surveys).

Data Analysis

Responses to the surveys were hand-tallied on spreadsheets (Appendix B). The number of responses, frequency distributions, and percentages were reported for each question. Responses representing the majority of teachers as well as general trends in responses were identified. Similarities and differences between mathematics and science teachers were analyzed. In some instances, data was disaggregated into three response categories based on the subject(s) taught: mathematics only, science only, or mathematics and science. Analysis of data by grade level taught or ESC region was not conducted.

Data analysis was complicated by inconsistencies in teacher responses. Some surveys were incomplete, one or more questions were not answered. In some cases, teachers selected more than the requested number of responses.

In some instances, totals of subgroups did not equal the total for that response. This occurred for several reasons. All percentages are rounded to the nearest whole percent so total may vary due to the impact of rounding. When analyzing grade levels, the total number of teachers by grade level exceeds the total number of surveys received. This is due to situations where a teacher is assigned to more than one grade level so the teacher is counted in both categories.

Chapter IV

Results

This section presents the analysis of teacher responses to the survey. Statistics describing the demographics of the sample are presented first. Survey responses were analyzed by region (number of schools and teachers responding), grade taught, and subject taught. The demographic results are followed by six sections, each corresponding to one of the six research questions previously discussed.

Sample Demographics

Table 1 shows the number of schools and teachers completing surveys in each region.

Table 1

Survey Responses by Region, Number of Schools and Number of Teachers

Region	Schools	Teachers
1	11	41
2	12	38
3	12	42
20	14	56

Fifty-six percent (56%) of the targeted schools returned surveys resulting in a survey response rate of 51% (177 surveys). In each region, the number of responding schools ranged from 11 to 14, with a range of completed surveys from 38 to 56. Survey responses appear to be fairly evenly distributed among the regions.

Table 2 shows the distribution of completed surveys by subject taught.

Table 2

Survey Responses and Subject(s) Taught

Subject	Percent of Teachers
Mathematics Only	28%
Science Only	16%
Mathematics and Science	58%

Teachers who taught both mathematics and science completed more than half (58%) of the surveys. The fewest number of responses were from science only teachers.

Table 3 shows the distribution of responses by grade taught.

Table 3

Survey Responses by Grade Taught

Grade	Percent of Teachers
4	36%
5	26%
6	9%
7	14%
8	15%

Nearly two-thirds (62%) of the surveys were completed by teachers in Grades 4 and 5. The lowest response rate was by teachers in Grade 6

In summary, the demographics indicate that surveys are representative of schools and teachers in the South Texas area and the results reflect the status of mathematics and science in South Texas.

Research Questions

The purpose of the survey was to acquire information from teachers to address each of the five research questions:

1. What are the perceived needs for educational reform in the areas of Middle School mathematics and science?
2. What are the components of national and state middle school mathematics and science curricular standards?
3. What are the common components of current middle school reforms in mathematics and science education?
4. What components are considered when developing applicable teaching practices?
5. What components are considered when implementing reformed-based professional development programs?
6. What are the components of an effective mathematics and science middle school?

Research Question 1: What are the perceived needs for educational reform in the areas of middle school mathematics and science?

To answer this question, the content needs of teachers were assessed. Table 4 shows the percentages of mathematics and science teachers rating their knowledge of content as "very well."

Table 4

Percent of Teachers Rating Their Knowledge of Content as "Very Well"

Subject(s) Taught	Knowledge of Math Content	Knowledge of Science Content
Mathematics only	100%	
Science only		86%
Mathematics and science	89%	56%

One hundred percent (100%) of those teaching only mathematics responded "very well" when assessing their knowledge of content. Science content was rated lower than mathematics content by both science-only and mathematics/science teachers. The area of greatest concern was in science content for mathematics/science teachers (56%).

This data shows a greater need in the area of science content than mathematics content. Teachers who teach two subject, mathematics and science, rate their knowledge lower than teachers who only teach one subject do. It may be inferred from this data that content wise, it is more difficult to have adequate knowledge in two content areas than in one area. Science content appears to be more problematic than mathematics content. The content problem associated with teachers who teach two subjects is of particular concern due to the interdisciplinary focus of the national standards and current reform initiatives of middle school grades.

Needs associated with instructional program implementation were also addressed through survey questions. Five barriers to effective instructional program implementation identified by teachers are shown in Table 5.

Table 5

Barriers to Implementation of Effective Instructional Programs

As Identified by Teachers

Subject Taught	Percentage of Teachers
Mathematics	
Too much focus on TAAS	26%
Limited planning time	18%
Limited instructional time	16%
Student apathy and discipline	16%
Inadequate textbooks	6%
Science	
Too much focus on TAAS	20%
Limited resources	18%
Limited instructional time	17%
Inadequate textbooks	13%
Student apathy and discipline	9%

Too much focus on the TAAS and limited instructional time were identified by both mathematics and science teachers. Mathematics teachers were more concerned with limited planning time (18%) and student apathy and discipline (16%) than science teachers. Science teachers were more concerned with limited resources (18%) and inadequate textbooks (13%).

In addressing research question 1, analyses of responses have identified several areas of need as perceived by middle grade teachers. Teaches who teach science identified a need for more knowledge in the area of science content. Too much focus on TAAS and limited instructional time were barriers identified by both mathematics and science teachers. Science teachers identified inadequate textbooks and mathematics teachers identified student apathy and discipline as barriers to effective instructional program implementation.

Research Question 2: What are the components of national and state middle school mathematics and science curricular standards?

An extension of research question 2 involved analyzing teachers' knowledge of and ability to apply national and state standards in mathematics and science. Table 6 shows percentages of teachers responding "very well" to their knowledge of and ability to apply national standards.

Table 6

Percentages of Teachers Responding "Very Well" When Assessing Knowledge of and Ability to Apply National Standards

	Knowledge of Standards	Ability to Apply Standards
Mathematics Standards		
Mathematics Only	46%	58%
Mathematics and Science	23%	26%
Science Standards		
Science Only	34%	34%
Mathematics and Science	14%	8%

The highest ratings were in the area of mathematics standards. Forty-six percent (46%) of mathematics-only teachers rated their knowledge of the National Mathematics Standards as "very well." Fifty-eight percent (58%) rated their ability to apply the national standards as "very well." The lowest ratings occurred in the area of science standards. Only 14% of the mathematics/science teachers rated their knowledge of national standards as "very well" and only 8% rated their ability to apply the national standards as "very well."

Teachers rated their "familiarity" with the TEKS, the state standards for Texas. Table 7 shows the percentage of teachers responding "very well" to "familiarity" with the TEKS.

Table 7

Percentage of Teachers Responding "Very Well"

When Assessing Familiarity with TEKS.

Subject Taught	Mathematics TEKS	Science TEKS
Mathematics only	83%	
Science only		83%
Mathematics and Science	86%	54%

Mathematics/science teachers rated their familiarity with the mathematics TEKS slightly higher than mathematics only teachers did and their familiarity with the science TEKS much lower than science only teachers did.

Analysis of data related to national and state standards shows that, in general, teachers are more knowledge of mathematics standards than science standards and more

familiar with the TEKS than the national standards. In all areas except for familiarity with the Mathematics TEKS, mathematics and science teachers had lower percentages than mathematics only and science only teachers. It is reasonable to expect that it is more difficult for mathematics and science teachers to have knowledge about and be able to apply four sets of standards when teaching two subjects compared to mathematics-only and science-only teachers who have just two sets of standards when teaching one subject.

Research Question 3: What are the common components of current middle school reform in mathematics and science education?

The review of literature identified integrated mathematics and science lessons and the use of scientific investigations as current reforms in middle grades education. Teachers were asked to rate their ability to develop an integrated lesson and to conduct a scientific investigation. Teacher responses by subject(s) taught are shown in Table 8.

Table 8

Percentage of Teachers Responding "Very Well" When Assessing Ability to Develop An Integrated Lesson and To Conduct a Scientific Investigation

Subject Taught	Integrated Lesson	Scientific Investigation
Mathematics only	28%	Not Applicable
Science only	39%	86%
Mathematics and Science	40%	52%

Teachers assessed their ability to develop an integrated mathematics/science lesson and to conduct a scientific investigation. Science-only and mathematics/science teachers rated their abilities (39% and 40%, respectively) to develop an integrated lesson

higher than mathematics only teachers (28%). Eighty-six percent (86%) of science-only teachers responded "very well" when assessing their ability to conduct a scientific investigation compared to a little more than half (52%) of teachers who taught both mathematics and science.

The data suggests that less than half of all teachers are adequately prepared to adopt reform initiative and develop integrated lessons. Mathematics-only teachers are less able to develop an integrated less than science-only and mathematics/science teachers. On the other hand, the low percentage may indicate that many mathematics teachers are not given the opportunity to develop an integrated lesson. Science/mathematics teachers are less prepared to conduct scientific investigations than science-only teachers.

Current reforms of middle grades education focus on students having the opportunity to be actively involved in learning. Daily use of calculators, computers, and mathematic manipulatives is stressed. Table 9 shows the percentages of teachers identifying daily availability of calculators, computers, and mathematic manipulatives to students.

Table 9

Percentages of Teachers Indicating Daily Availability of Resources to Students

Subject Taught	Calculators	Computers	Math Manipulatives
Mathematics only	89%	50%	90%
Science only	57%	64%	50%
Mathematics and Science	82%	72%	85%

Daily availability of mathematic manipulatives and calculators is greatest in the mathematics only classes (90% and 89%, respectively). Daily computer availability is highest in mathematics/science classes (72%) and lowest in mathematics-only classes (50%). Calculators are less available in science-only classes than other classes.

Availability of resources is not enough to ensure an effective program that emphasizes the physical and intellectual involvement of students. Teachers identified the number of lesson during a typical week in which students were actively involved with mathematic manipulatives, science equipment or in which students observed a teacher directed science demonstration. All teachers had the opportunity to indicate the number of lessons involving mathematic manipulatives. Only science teachers responded to science equipment and demonstration lessons. Table 10 shows the number of lessons in a typical week in which mathematic manipulatives and science equipment are used.

Table 10

Number of Lessons During a Typical Week

In Which Mathematic Manipulatives and Science Equipment Are Used

Lessons Per Week	Math Manipulatives	Science Equipment	Science Demonstration
5	5%	4%	1%
4	8%	2%	1%
3	30%	9%	12%
2	34%	22%	13%
1	18%	32%	34%
0	5%	27%	34%
Not Applicable	5%	6%	1%

Almost half (43%) of the mathematics teachers indicated that students used mathematic manipulatives in 3 or more lessons during a typical week. Only 15% of the science teachers indicated that students used science equipment 3 or more times per week and only 14% of the science teachers indicated they did a science demonstrations each week. Ninety-five percent (95%) of the mathematics teachers had at least one lesson per week involving mathematic manipulatives. Less than 3/4 (73%) of the science teachers had at least one lesson per week involving science equipment. Two-thirds (66%) of the science teachers did at least one demonstration per week. During a typical week, 5% of the mathematics teachers did not have a lesson using mathematic manipulatives and 27% of the science teachers did not have a lesson using science equipment. Over 1/3 of the science teachers (34%) did less than one science demonstration per week.

A comparison between data reported on Table 9 and Table 10 show that availability of manipulatives does not guarantee that they are will used by students. The data indicates that current instructional programs are not aligned with TEKS and National Standards that prescribe students being actively involved with learning.

Research Question # 4: What components are considered when developing applicable teaching practices?

The literature review identified several instructional methods that are critical components of reform initiatives in mathematics and science education. Teachers were asked to identify three reform initiatives that are most effective in creating the ideal classroom. Table 11 shows the instructional methods most frequently identified by

teachers as being the most effective when creating an ideal mathematics and/or science classroom.

Table 11

Instructional Methodologies Identified by Teachers as Being

Most Effective In Creating the Ideal Classroom

Subject Taught	Percentage of Teachers Selecting Method
Mathematics	
Hands-on activities	33%
Problem Solving activities	21%
Utilize technology	15%
Science	
Hands-on activities	34%
Inquiry and experimental	29%
Utilize technology	17%

In both mathematics and science classes, hands-on activities and technology were identified as two of the three most effective instructional methods. One out of three teachers identified hands-on activities as being important. Fifteen percent (15%) of the mathematics teachers and 17% of the science teachers identified technology as an instructional method.

The instructional methods identified by the teachers were some of the same effective instructional methods identified in the literature review. The national mathematics and science standards promote instructional methods that focus on hands-

on, problem-solving, and inquiry and experimental activities along with use of technology. Analysis of data from Table 11 shows that teachers are aware of what instructional methods are needed to create the ideal classroom.

Teacher involvement in curriculum development was identified in the literature as a critical component for effective mathematics and science programs. Table 12 shows the percentage of teachers responding "very well" when assessing their input during curriculum implementation in their subject area.

Table 12

Teachers Responding "Very Well"

When Assessing Input during Curriculum Implementation

Subject Taught	Mathematics Curriculum	Science Curriculum
Mathematics only	76%	
Science only		68%
Mathematics and science	53%	32%

When implementing the mathematics curriculum, 76% of the mathematics teachers rated the degree of input as "very well", compared to only 53% of the mathematics and science teachers. When compared to mathematics/science teachers, twice as many science-only teachers responded "very well" when describing their input (32% and 68%, respectively).

Generally, single-subject teachers (mathematics-only or science-only) indicate that they have more input during curriculum implementation than two-subject teachers (teaching both mathematics and science). Teacher input was greater for the mathematics

curriculum than for the science curriculum. This may indicate that mathematics teachers may have a greater impact when initiating reforms.

Reforms in mathematics and science education have identified instructional strategies that are more effective than traditional methods. From a list of traditional and reform-related instructional strategies, teachers identified strategies they used most frequently during a typical week and those that were used the least frequently. Table 13 shows the three instructional methods used most during a typical week and three instructional methods used during a typical week.

Table 13

Instructional Methods Used During a Typical Week

Instructional Method	Percentage of Teachers Using Method	
Used Most Frequently	Mathematics	Science
Seat Work	31%	32%
Hands-on Activities	20%	21%
Problem-solving Activities	35%	16%
Used Least Frequently		
Technology	33%	31%
Inquiry and Experimental Methods	21%	18%
Authentic Tasks	19%	16%

Problem solving was more frequently used in the mathematics classroom (35%) while seatwork was the most frequently used method in science classes (32%).

Technology was the least used instructional method in both mathematics and science classrooms

Data concerning instructional methods currently used Table 13) was compared to instructional methods identified by teachers as being most effective in creating the ideal classroom (Table 11). Mathematics teachers appear to be applying what they know about effective instructional methods to current classroom practices. Hands-on activities and problem-solving activities were identified as effective methods in the ideal classroom and were also identified as the methods currently used most frequently in mathematics classrooms. In science classes, hands-on activities were identified with an ideal classroom and also as one of the most frequently used methods in current instruction. For both mathematics and science classroom, the largest discrepancy was in the area of technology. Although both mathematics and science teachers identified technology with the ideal classroom, it was the instructional method used least frequently by the same teachers. Whether this discrepancy was due to lack of computers, lack of teacher expertise in technology, or to another factor, was not addressed by the survey. The most frequently used method in the mathematics classroom was problem-solving activities. The data did not indicate if problem solving involved computations with word problems and other textbook based problems or if it described an inquiry based approach to solving complex real-world problems.

In summary, the data suggests that when implementing applicable teaching practices, attention should be focused on the use of technology in both mathematics and science classrooms, and inquiry and experimental methods in science classrooms. Further clarification of the "problem-solving" as it related to the mathematics classroom is

needed. Mathematics teachers indicated that they have more input during curriculum implementation than science-only or mathematics and science teachers. This would suggest that changes in teacher behaviors and instructional methods would more likely impact the mathematics curriculum than the science-only curriculum.

Research Question 5: What components are considered when implementing reformed-based professional development programs?

To effect program reform, it is necessary to change teacher behaviors. This is traditionally accomplished through professional development programs. Teachers indicated the number of hours spent in professional development activities related to mathematics and/or science during the previous year. Table 14 shows percentages of mathematics teachers and science teachers and the number of hours they participated in subject-related professional development activities.

Table 14

Hours of Subject-Related Professional Development Activities During the Previous Year

Hours	Mathematics Teachers	Science Teachers
20+	23%	10%
15-19	16%	4%
10-14	15%	5%
5-9	22%	19%
1-4	14%	29%
0	8%	31%
Not applicable	1%	1%

During the year, more than twice as many mathematics teachers had 20 or more hours of subject-related professional development than science teachers had. Over half (54%) of mathematics teachers participated in at least 10 hours of professional development during the past year. In contrast, only 19% of the science teachers had the same amount of professional development. Almost one-third (31%) of the science teachers had no (0 hours) subject-related professional development compared to only 8% of mathematics teachers.

During the past year, mathematics teachers participated in more subject-related professional development hours than science teachers. Whether this difference was due to teacher choice or availability of subject-related activities was not addressed by this study. This data identifies a need for science related professional development programs.

Curriculum-related professional development topics such as National Standards, TEKS, TAAS, and performance-based assessments are associated with current reform initiatives in mathematics and science. Table 15 shows the curriculum-related professional development topics identified by teachers as being most beneficial improving and updating teaching effectiveness.

Table 15

Curriculum-Related Professional Development Topics Identified by Teachers As Being Most Beneficial in Improving and Updating Teaching Effectiveness

	Teachers	
Topic	Mathematics	Science
National Standards	25%	24%
TEKS/Curriculum Development	24%	25%
Subject Matter Content/Knowledge	18%	21%
Assessment (TAAS Format)	7%	10%
Performance-Based Assessment	25%	21%

There is diversity among mathematics and science teachers as to which curriculum-related professional development programs are the most beneficial in improving and updating teaching effectiveness. Mathematics teachers identified three topics as almost equally important: National Standards (25%), TEKS and Curriculum Development (24%), and Performance-based assessment (25%). Science teachers identified four topics: National Standards (24%), TEKS and Curriculum Development (25%), Performance-based assessment (21%), and Subject Matter Content/Knowledge (21%). The least selected area for both mathematics and science was Assessment – TAAS Format (7% and 10%, respectively).

Teachers also identified curriculum-related topics in which they had the most professional development experience. Table 16 shows curriculum-related professional development topics in which teachers had the most experience.

Table 16

Curriculum-Related Professional Development Topics

In Which Teachers Have The Most Experience

Topic	Mathematics	Science
National Standards	1%	3%
TEKS and Curriculum Development	24%	27%
Subject Matter Content/Knowledge	37%	43%
Assessment (TAAS Format)	33%	16%
Performance-Based Assessment	5%	11%

Mathematics and science teachers indicated they had the most professional development experience in their subject areas (37% and 43%, respectively). Almost twice as many mathematics teachers (33%) had experience in TAAS related program than science teachers (16%). Approximately one-fifth of the mathematics teachers (24%) and the science teachers (27%) had the most experience in the area of TEKS and curriculum development.

There is a discrepancy between professional development activities teachers identify as most beneficial and those in which they have the most experience. Mathematics and science teachers viewed National Standards and Performance-Based Assessment almost equally important when compared to TEKS and Subject Matter professional development activities. This position is not supported by their participation in professional development activities. Both mathematics and science teachers had the least experience in National Standards and performance-based assessment. Whether this

discrepancy is due to teacher choice or the availability of professional development activities is not addressed by this study.

From a list of eight instruction-related professional development activities, teacher identified four as most beneficial in improving and updating teaching effectiveness. Table 17 shows the four professional development topics identified as being most beneficial in improving and updating teaching effectiveness.

Table 17

Instruction-Related Professional Development Topics Identified by Teachers As Most Beneficial In Improving and Updating Teaching Effectiveness

	Percentage of Teacher Responses	
Topic	Mathematics	Science
Hands-On Instruction	18%	23%
Use of Authentic Tasks	21%	19%
Professional Development with follow-up and planning time	17%	18%
Technology	15%	14%

Use of authentic tasks (21%) was the most frequently selected program by mathematics teachers, followed by hands-on activities (18%), and technology (15%). To improve and updating teaching effectiveness in the science program, the first choice was hand-on activities (23%), followed by use of authentic tasks (19%), and technology (14%).

In response to research question 5, data shows that although teachers are aware of the types of instruction-related professional development activities that are most beneficial in improving and updating teaching effectiveness, they are not implementing the strategies in their classrooms. Use of authentic tasks and technology, identified as being beneficial, were two instructional strategies that were used the least frequently during a typical week (see Table 13). Teachers also indicate that to be effective, professional development must include follow-up and adequate collaborative planning time.

Research Question 6: What are the components of an effective model mathematics and science middle school?

When developing plans for the Texas A&M University – Corpus Christi Mathematics and Science Middle School Academy, four strategies, designed to facilitate the improvement of mathematics and science teaching. These strategies were identified by Dr. Jane Wilhour, Director of the Early Childhood Development Center, Texas A&M University-Corpus Christi (personal communication, January 17, 2000). Table 18 shows percentages of teachers selecting each activity.

Table 18

Professional Development Activities in Which Teachers Would Participate

Activity	Percentages
On-line resources for innovative mathematics/science activities	52%
Small group training in evaluating and adjusting curriculum to to increase student activities	50%
Intense week-long training focusing on the integration of mathematics and science activities and the application of hands-on, inquiry techniques	47%
Observation of master teachers modeling instructional strategies strategies with your students to improve your teaching methodologies	55%

Teachers selected from 0 to 4 activities in which they would choose to participate. Approximately equal numbers of teachers selected each activity. Observations of master teachers received the most responses (55%). Responses by teaching professionals shows that professional development strategies planned for the Middle School Academy are on target with teacher interests and needs. These components should be assessed when developing the professional development program.

Chapter V

Summary

The purpose of this study was to identify current educational reform issues that increase student achievement in mathematics and science in Texas middle schools. Areas of research included student needs, science and mathematical standards (both state and national), teaching practices, staff development and components of a model mathematics and science middle school. The specific research questions of this study were:

- What are the perceived needs for educational reform in the areas of Middle School mathematics and science?
- What are the common components of national and state middle school mathematics and science curricular standards?
- What are the common components of current middle school reforms in mathematics and science education?
- What components are considered when developing applicable teaching practices?
- What components are considered for implementing reformed-based professional development programs?
- What are the components of an effective mathematics/science middle school?

A survey was conducted with one hundred seventy-seven (177) middle grade mathematics and science teachers from four South Texas educational regions. (Schools responded at a 56 percent return rate.) The data used for the analysis of this study was based on surveys seeking data on the perceived areas of need for South Texas middle school teachers of mathematics and science.

Survey results indicate a discrepancy in content knowledge, instructional methodologies utilized, program implementation, and hours of content-related professional development activities between mathematics-only, science-only and mathematics and science teachers. Mathematics teachers rated their abilities associated with content, curriculum standards, and program implementation higher than either science-only or mathematics and science teachers. Science-only teachers rate their abilities in these areas higher than teachers who teach both mathematics and science do. Except in the area of "developing integrated lessons," dual subject teachers indicated lower ratings than single-subject teachers did. Single-subject teachers were more knowledgeable about their subject areas than dual subject teachers. Less than half of the teachers rated their ability to develop an integrated lesson as "very well." Survey results indicated that teachers are more prepared to teach single subjects such as "mathematics only" than to teach dual subjects such as "mathematics and science".

The survey indicated a discrepancy between knowledge and implementation concerning instructional methodologies. Literature and teacher responses indicate hands-on activities are most important to creating the ideal classroom, but most indicate that seatwork was used most frequently. Teachers indicated that technology was important but it was one of the instructional methodologies utilized least frequently used during the week. Available resources such as mathematic manipulatives, calculators, and computers, do not appear to be frequently used in the classroom. In order to implement more effective programs, teachers indicated a need for more professional development programs focusing on national standards, integrated lessons, performance-based assessment, authentic tasks, hands-on activities, and technology.

National and state mathematics standards identify mathematical areas in which grades should focus upon. Fractions and decimals are introduced in Grade 4 and further developed in

Grade 5. The end of Grade 5 should complete whole number instruction. In Grades 6-8, the focus is on proportional reasoning and the relationship between fractions, decimals and percents. Geometric concepts, probability, statistical measures, and computations with fractional and decimals should be emphasized (NCTM, 1999; TEA, 1998).

National and state science standards promote the integration of life, earth, and physical science concepts. Fewer topics, in greater depth, are investigated. Students are involved in investigating real-world problems that are applicable to current and future human needs. Field and laboratory experiences involve the collection and analysis of data as well as communication of the results. (AAAS, 1995; NSTA, 1998; TEA, 1998).

Conclusions

When considering the review of literature and the analysis of survey data, numerous areas of effective implementation can be concluded for an effective mathematics and science middle school. The areas include content knowledge, instructional methodologies utilized, program implementation, and hours of content-related professional development activities between mathematics, science and mathematics and science teachers.

The survey and literature review indicated an inherent need for content knowledge in both mathematics and science teachers. In general, survey results implied a greater need in the area of science education than mathematics education and for teachers who teacher both subjects than for single subject teachers. Teachers who taught a single subject such as mathematics or science only were more equipped with content knowledge than the teachers who taught both science and mathematics. The literature and survey responses implied that directed attention has not been given to preparing dual subject teachers for greater responsibilities associated with two subjects, therefore leaving them unprepared in one or both areas.

The survey results show that even though teachers are cognizant of the most effective instructional methodologies, they are not implementing these methodologies. The teachers were aware of what it takes to have an effective classroom however they were not practicing those teaching methods. "Seatwork" seemed to be the most common practice among teachers. Survey data and literature review imply that teachers acknowledge the importance of technology integration in the classroom but it is one of the least instructional methodology implemented. Literature and the survey indicated that professional development programs that are content related are needed. They should include follow-up and adequate collaborative planning time. Even though greater needs were identified in the area of science, mathematics teachers indicated more hours in content-related professional development activities than science teachers did. The data implied that it is critical that specific needs of teachers be reflected in the types of professional development programs offered and that teachers in all areas have equal access to appropriate subject-specific programs.

Recommendations

The following specific recommendations for the Mathematics/Science Middle School have been written based upon the analysis of survey responses and information obtained through the literature review. Recommendations encompass national and state standards, middle school reform, applicable teaching practices, and effective professional development.

Educational Reform

The following are three key components recommended for the Mathematics/Science Middle School that will enable its ability to enhance middle school reform in South Texas.

- The implementation of interdisciplinary teaming. A core of teachers will be assigned to the same group of students.

- The implementation of varied instruction including integration of learning experiences, addressing students' questions and focusing upon real life issues relevant to students in South Texas. This also includes actively engaging students in problem-solving activities, and emphasizing collaboration through cooperative learning and interpersonal communication.
- The implementation of exploratory programs exposing students to a range of vocational, academic, environmental, and recreational areas. The students may consider these areas for career options, community service, enrichment, or enjoyment.

It is strongly recommended that through the implementation of these programs that the Mathematics/Science Middle School emphasizes high content standards and high expectations.

Teaching Practices

It is recommended that the following specific teaching practices be implemented at the Mathematics/Science Middle School.

- The curriculum should demand depth over breadth calling for greater concentration on a significant core of skills. The teachers will teach a few significant skills in order to teach more effectively. Instruction needs to be inquiry-based with little or no lecture.
- The curriculum should emphasize the development of the students' reasoning abilities and problem solving abilities rather than concentrating on rote memory. Topics in probability and statistics deserve substantial treatment and are recommended over the traditional curricula.
- As much as possible, the teaching should incorporate hands-on activities. The Middle School should involve multi-sensory laboratory-oriented projects. It is also strongly

recommended that teaching activities and assessment incorporate real-world problems, tasks, and manipulatives.

- Assessment needs to involve other interdisciplinary tools such as classroom observations, journal writing, written explanations, inventions, open-ended problems, and ongoing projects while the students are there.
- The Middle School should provide students the opportunity to apply mathematical and science ideas and techniques to the exploratory programs exposing students to a range of vocational, academic, environmental, and recreational areas mentioned in prior recommendations. Tasks should be based on contexts that are familiar to South Texas students through their homes, schools, communities, or environments.
- It is recommended that the Mathematics/Science Middle School utilize the tools of technology through integration in the classroom. A variety of technologies can be used to help the students to explore, experiment, and visualize mathematical and science ideas.

Professional Development

The following recommendations can be made regarding the needs of teachers for professional development. Professional development must incorporate the following initiatives to secure effectiveness.

- Training should focus on teachers as the central key to student learning; yet include all other members of the school community.
- Training should enable teachers to develop further expertise in subject content. It should focus on content knowledge with emphasis on national and state standards.
- Training should be focused on implementing effective teaching methodology.

- Professional development should enable teachers to develop further expertise in the use of technologies as tools of integration rather than tools of management.
- Those who will participate in and facilitate that development should plan training collaboratively.
- Professional development should be evaluated ultimately on the basis of its impact on teacher effectiveness and student learning; and this assessment guides subsequent professional development efforts.
- Training should be sustained, ongoing, intensive, and supported by modeling, coaching, and the collective solving of specific problems of practice.

Recommendations for Further Studies

Increasing the amount of time provided for research and survey data response would enhance future research in this area. Qualitative components would also enhance the findings in this study. It is also recommended that possible visitation of effective middle schools and mathematics and science academies are utilized.

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Appendix A

Please complete the following information if you would like to be added to the future mailing list of the Texas A&M University-Corpus Christi Middle School Math/Science Center.

Name:_____

Mailing Address:_____

_____

E-Mail:_____

Thank you for your cooperation and time. Please return to:
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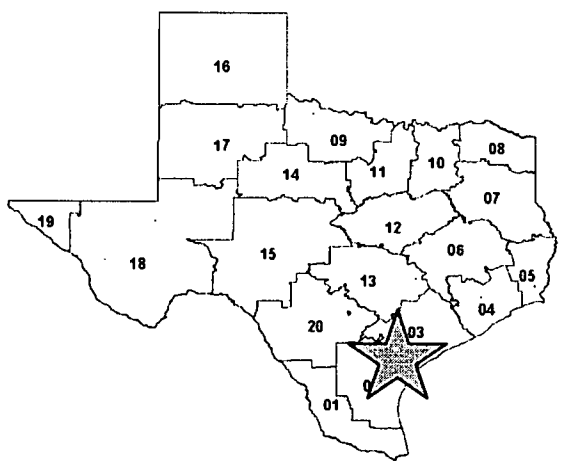
South Texas Research and Development Center.



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Texas A&M University-Corpus Christi
The Island University

TEXAS A&M UNIVERSITY KINGSVILLE

March 4, 2000

Dear Educator,

Exciting things are on the horizon for math and science educational reform in South Texas.

Texas A&M University-Corpus Christi is proposing the creation of a Middle School Math/Science Center. The focus of this innovative center will be to improve the teaching of math and science in Texas schools. Both professional development and undergraduate teacher education instructional activities will be conducted in the Center. These activities will involve fourth through eighth grade students from Texas schools.

An exciting component of this project is a week long residential Academy in which students and their teachers participate in math/science investigations. Master teachers will model effective instructional methodologies for the teachers while students participate in authentic research investigations. National and state reforms, hands on applicable strategies, and innovative math and science curricula will be integrated into interdisciplinary environmental units.

This study is being conducted by four public school teachers who are enrolled in a graduate education course at TAMU-CC. Your responses will help the teachers create the guiding parameters for the Center.

It is imperative to develop a program that is based on the needs of current teachers and one that reflects math/science reform in Texas. The quality of the study is dependent upon a high participation rate. Your assistance is vital to the success of this program, as the information can only be obtained from professionals such as you.

Thank you in advance for your honest replies and prompt response.

We hope to see you one day at the TAMU-CC Middle School Math/Science Center.

Sincerely,

Dr. Thomas H. Linton, Ph.D.
Executive Director, South Texas Research and Development Center
Texas A&M University-Corpus Christi

25. **Select the two (2) instructional methodologies utilized the MOST in a typical week in each subject you teach.**

	Math	Science
Seat Work: Worksheets/Textbook Based Assignments	O	O
Hands-On Activities	O	O
Problem Solving Activities	O	O
Inquiry and Experimental (Scientific Method)	O	O
Utilize technology (computer, laser disc, calculators, Internet)	O	O
Use of authentic tasks	O	O
Assessment	O	O
Other: _____	O	O

26. **Select the two (2) instructional methodologies utilized the LEAST in a typical week in each subject you teach.**

	Math	Science
Seat Work: Worksheets/Textbook Based Assignments	O	O
Hands-On Activities	O	O
Problem Solving Activities	O	O
Inquiry and Experimental (Scientific Method)	O	O
Utilize technology (computer, laser disc, calculators, Internet)	O	O
Use of authentic tasks	O	O
Assessment	O	O
Other: _____	O	O

27. **Select what you perceive to be the two (2) MOST effective instructional methodologies in creating the ideal math and/or science classroom given there are no barriers (i.e. money, equipment, time) in each subject you teach.**

	Math	Science
Seat Work: Worksheets/Textbook Based Assignments	O	O
Hands-On Activities	O	O
Problem Solving Activities	O	O
Inquiry and Experimental (Scientific Method)	O	O
Utilize technology (computer, laser disc, calculators, Internet)	O	O
Use of authentic tasks	O	O
Assessment	O	O
Other: _____	O	O

	Not at All Well	Somewhat Well	Very Well	Does Not Apply
9. **How would you rate your degree of input when implementing the math curriculum?**	O	O	O	O
10. **How would you rate your degree of input when implementing the science curriculum?**	O	O	O	O
11. **How would you rate your ability to develop an integrated math/science lesson?**	O	O	O	O
12. **How would you rate your ability to effectively conduct a scientific investigation with your students?**	O	O	O	O
13. **How would you rate your knowledge of the content in the math course(s) you teach?**	O	O	O	O
14. **How would you rate your knowledge of the content in the science course(s) you teach?**	O	O	O	O

15. **If teaching math, on the average, how many lessons per week are students actively involved with math manipulatives?**

O 5 lessons O 4 lessons O 3 lessons O 2 lessons
O 1 lesson O 0 lessons O Not Applicable

16. **If teaching science, on the average, how many lessons per week are students actively involved in utilizing laboratory equipment?**

O 5 lessons O 4 lessons O 3 lessons O 2 lessons
O 1 lesson O 0 lessons O Not Applicable

17. **If teaching science, on the average, how many times per week do you use laboratory equipment during a demonstration?**

O 5 lessons O 4 lessons O 3 lessons O 2 lessons
O 1 lesson O 0 lessons O Not Applicable

18. **In the last year, how many hours have you spent on professional development in the area of math?**

O 20+ hours O 15-19 hours O 10-14 hours O 5-9 hours
O 1-4 hours O 0 hours O Not applicable

19. **In the last year, how many hours have you spent on professional development in the area of science?**

O 20+ hours O 15-19 hours O 10-14 hours O 5-9 hours
O 1-4 hours O 0 hours O Not applicable

20. **Select the three (3) areas which MOST prevent you from implementing a more effective instructional program in each subject you teach.**

	Math	Science
Student apathy/discipline	O	O
Inadequate Professional Development	O	O
Lack of Administrative Support	O	O
Inadequate Textbooks	O	O
Too much focus on TAAS	O	O
Limited Planning Time	O	O
Limited Instructional Time	O	O
Limited resources (i.e. technology, manipulatives, science equipment)	O	O
Liability in Science labs	O	O

21. **Select the two (2) professional development areas in which you have the MOST experience in each subject you teach.**

	Math	Science
National Standards	O	O
TEKS/Curriculum Development	O	O
Subject Matter Content / Knowledge	O	O
Assessment (TAAS Format)	O	O
Performance-Based Assessment	O	O

22. **Select the two (2) professional development areas in which you have the LEAST experience in each subject you teach.**

	Math	Science
National Standards	O	O
TEKS/Curriculum Development	O	O
Subject Matter Content / Knowledge	O	O
Assessment (TAAS Format)	O	O
Performance-Based Assessment	O	O

23. **Select the three (3) professional development programs you believe would be MOST beneficial in improving and updating your teaching effectiveness in each subject you teach.**

	Math	Science
Hands-On Instruction	O	O
Cooperative Learning	O	O
Textbook Utilization	O	O
Technology	O	O
Learning Styles / Multiple Intelligences	O	O
Use of Authentic Tasks in math and/or science	O	O
Interdisciplinary Team Organization / Instruction	O	O
Follow up Professional Development and adequate Collaborative Planning Time	O	O

24. **Select the two (2) professional development programs you believe would be MOST beneficial in improving and updating your teaching effectiveness in each subject you teach.**

	Math	Science
National Standards	O	O
TEKS/Curriculum Development	O	O
Subject Matter Content / Knowledge	O	O
Assessment (TAAS Format)	O	O
Performance-Based Assessment	O	O

Please answer each question to reflect what currently exemplifies your classroom instruction and your professional development in math and science. Your cooperation is needed to make the results of this survey comprehensive, accurate, and timely.

1. **Identify the grade level(s) at which you are currently teaching.**
   O Grade 4 O Grade 5 O Grade 6 O Grade 7 O Grade 8

2. **Identify the subject you are currently teaching.**
   O Math
   O Science
   O Math and Science (separate classes)
   O Math and Science (integrated)

Currently, there is much discussion of the need to establish new higher standards for student achievement in the areas of math and science education. Answer the following questions in light of these standards.

	Not at All Well	Somewhat Well	Very Well	Does Not Apply
3. **How would you rate your knowledge of the National Standards in Math? (NCTM)**	O	O	O	O
4. **How would you rate your knowledge of the National Standards in Science? (NSTA)**	O	O	O	O
5. **How well equipped are you to apply National Standards in Math?**	O	O	O	O
6. **How well equipped are you to apply National Standards in Science?**	O	O	O	O
7. **How familiar are you with the Math TEKS?**	O	O	O	O
8. **How familiar are you with the Science TEKS?**	O	O	O	O

28. **If available, in which of the following activities would you choose to participate? You may select more than one.**
   _____On-line resources for innovative math/science activities for the classroom.
   _____Small group training in evaluating and adjusting current curriculum to increase student activities.
   _____Intense week-long training focusing on the integration of math and science activities and the application of hands-on, inquiry techniques.
   _____Observation of master teachers modeling instructional strategies with **your** students to improve your teaching methodologies.

29. **Do your students have daily access to the following resources in your math and/or science classroom?**

	Yes	No
Calculators	O	O
Computers	O	O
Math Manipulatives	O	O

30. **Approximately how much money is spent for instructional supplies in your subject area(s) each year?**

   O $_____:District/School Money

   O $_____:Personal Money

   O Do not know

- -

Please use the space below for any comments you may have regarding this survey or the development of the Texas A&M University-Corpus Christi Middle School Math/Science Center

(Go on)

SE064487

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