THE PURPOSE AND IMPLEMENTATION OF NATIONAL MATHEMATICS CURRICULUM STANDARDS

An Honors Thesis (HONRS 499)

by

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INTRODUCTION

The mathematics education in the American school system is not fulfilling the needs of today's children. Changes are needed to bring our nation's students to a level at which they can lead successful lives, both in everyday situations and as a part of the American work force. Not enough of our students are reaching the mathematics level required to support a technological nation. The United States is far behind other nations in mathematics education. (10, p.74) This leads to an inability to compete in the international workplace. The National Commission on Excellence in Education researched the American educational system extensively and has reported the following:

Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. The educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people. . .If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. (7, p.5)

The National Council of Teachers of Mathematics Curriculum and Evaluation Standards for School Mathematics (1989) has confronted the problems of mediocrity related to school mathematics. The American mathematics school curriculum is extremely outdated and needs much improvement. (10, p.74) Research has shown that the mathematics
curriculum in today's schools is about 500 years old. (11, p.4) This curriculum is no longer adequate nor appropriate for the technology used by everyone in today's society. When implemented, the Standards will better prepare our children for today and tomorrow's technological advances, will adapt teaching methods to children's learning styles, and will encourage a positive attitude about mathematics in all students. The National Council of Teachers of Mathematics has accomplished a great deal over the last several years, but many challenges still lie ahead for improving our nation's mathematics education.
CHANGES ARE NEEDED

In order to improve the United States educational system, changes must occur on all levels. Reforms are needed in every school system across the country, as well as on the state and national levels. Much more is expected of today's youth than the youth of years gone by when a young person could prosper in life without even a high school diploma. Students of today face a technological world which requires a high level of mathematics both on the work force and in everyday life. The attitude of students and the general public towards mathematics education is surprisingly low at a time when learning mathematics is crucial. Many changes must occur in the next few years to reshape the American educational system.

Need for a National Program

The present mathematics education program has little to offer to this country's young people. This massive program has had no national structure to tie everything together. Mathematics education needs national leadership to build the curriculum step by step and to assure students receive the mathematics they need to enter a profession and society. Local programs tend to remain only local, therefore, change needs to occur at a national level, affecting the educational system as a whole. (10, p. 18) The National Research Council urges that the only way to truly improve our country's mathematics education is to completely
redesign the curriculum and the way it is taught. Changing only parts of the system is not enough. (11, p.1)

The time has come for change in our nation's mathematics curriculum. The national curriculum must be supported by students, parents, teachers, administrators, government officials, and the general public. "[The NCTM Standards] represents the first effort ever to establish national expectations for school mathematics." (10, p.89) Superior education in mathematics requires agreement by all on the national level on the standards and goals to be set, in addition to flexibility for local adaptation. The NCTM Standards supports this view.

Living in a Technological World

"Since mathematics is the foundation of science and technology, it serves as a key to opportunity and careers." (10, p.3) The mathematics needed to enter and stay on today's work force increases daily. We are living in a technology-based world, in which too few of our students are reaching the mathematics level required to support a technological nation. "Over 75 percent of all jobs require proficiency in simple algebra and geometry." (10, p.4) In the past only a very small percentage of students continued education in college. Most needed only to learn the basic skills required in factories or on farms. These figures are now reversed. (10, p.11) Today's mathematics curriculum should reflect these changes.
Many high school graduates have not grasped the mathematical concepts needed to fully participate in our society as workers and citizens. The shortcut solutions in existence today are extremely inefficient, wasting monetary and human resources. Sixty percent of college students enrolled in mathematics courses are studying concepts which are taught in high school. (10, p.13) Many of those who enter the work force must take remedial mathematics courses. Industry spends as much on this remediation as is spent in schools and universities on their mathematics education. "The best way to teach mathematics is to teach it well the first time." (10, p.13)

Computers and Calculators

Computers and calculators are not only frequently used in job situations but also in the home and community. Everyone, especially our youth, must learn how to efficiently use computers and calculators to successfully function in today's society. What past generations accomplished using paper-and-pencil computations is now being done many times faster by these machines. (10, p.83) Almost all of the mathematics taught in kindergarten through the second year of college can be performed on a hand-held calculator. (11, p.2) Our mathematics curriculum must keep up with the times.
International Competition

The U.S. lags far behind other world-leading nations in mathematics education, thus, crippling our ability to compete. The future of this nation depends on the skills of the youth of today, and our children are not prepared to meet the future challenges. (4, p.50) Many studies have been conducted, comparing the United States educational system with those of other world-leading countries, especially Japan. The results have shown that only the top five percent of American high school students reach the same level of achievement as the average Japanese high school student. (4, p.8) "Our national goal must be to make U.S. mathematics education the best in the world." (10, p.88)

Informed Citizens

Mathematics permeates our everyday lives in many ways. Mathematics is needed for basic living. This includes comparing interests rates, determining risks, and interpreting scaled drawings and maps. Mathematics is needed to understand public policies, vote intelligently, and take part in society. Tax rates, public health data, and environmental statistics are just a few of the issues that concern us today. Mathematics is also present in many leisure activities and can actually be fun. Some examples include strategy games, puzzles, lotteries, and gambling. (10, pp.32-33) Students must study a wide range of mathematics areas; not only arithmetic, but also estimation,
measurement, geometry, statistics, and probability. All of these mathematical topics occur in everyday life. (10, p. 46)

**Mathematics Education**

The mathematics program at the elementary level greatly affects students' success in later school years. Elementary mathematics builds the foundation for future learning. For example, without the basic concepts, students cannot solve algebra and geometry problems in high school courses. Studies are showing that students are not measuring up to the expectations of this technological society. As many students progress through the American school system, their mathematics achievement falls further and further behind the generally accepted curriculum at each grade level. (4, p. 16)

As stated earlier, this problem continues to grow at the college level, where these students who lag behind must pass remedial mathematics classes before beginning their courses of study.

**Equality**

All students must have the chance to excel in mathematics. Minorities, females, and physically disabled persons have been discriminated against in the past. Minorities lack good role models of minorities in the teaching field. In the next few years, thirty percent of public school children will be minorities. (10, p. 21)

Research has shown that gender differences do not effect ability or interest in mathematics until the teenage years.
"Gender differences in mathematics performance are predominantly due to the accumulated affects of sex-role stereotypes in family, school, and society."(10, p.21) We must work to undo the effects of stereotypes before girls begin to choose not to study mathematics. Mathematics also offers many opportunities to physically disabled persons because it requires no physical skills. Not enough teachers recognize this opportunity.(10, pp.23-24)

Students of all ability levels have been discriminated against. High-achieving students are often left to fend for themselves as teachers work with those students who are having more problems. Equality means that each and every student has the opportunity to reach his or her potential. (10, p. 29) Gifted students must be challenged. On the other hand, many average and below average students never get the chance to explore mathematics beyond the textbook. Unlike in the past when the opportunity to learn and excel in mathematics was only offered in special programs for the gifted and talented, the NCTM Standards strive to promote equity and excellence for all students.(10, p.81) Mathematics should not separate our students into a small elite group with everyone else left out. "Mathematics must become a pump rather than a filter in the pipeline of American education."(10, p.7)
Independent Thinking

High-order thinking skills should be stressed in today's mathematics education. Students should learn to: search for solutions, not just learn procedures; investigate patterns, not just memorize formulas; and form their own theories, not just complete practice and drill exercises. (10, p. 84) High-order thinking skills must be blended with procedures and formulas. "Either extreme--mindless abstraction or mindless calculation--yields mindless mathematics."(10, p. 10) Studying mathematics should help children become independent thinkers.

Hands-on Learning

In surveys conducted by the National Assessment of Educational Progress from 1978 to 1986, little change was evident in the way students were taught mathematics. During this same time period research had been presented showing that children learn best from hands-on experiences, not rote memorization.(4, p. 76) The fact that teachers have not changed their methods in light of this evidence is a truly disconcerting matter. The solution to this problem will not come easily because "most teachers teach as they were taught, not as they were taught to teach."(10, p. 6)

In a student-centered classroom the role of the teacher changes from that of an authority to a facilitator of learning, and the students become active instead of passive in their own learning. As defined by the National Research
Council, a student-centered environment will:

- encourage students to explore;
- help students verbalize their mathematical ideas;
- show students that many mathematical questions have more than one right answer;
- provide evidence that mathematics is alive and exciting;
- teach students through experience the importance of careful reasoning and disciplined understanding;
- and build confidence in all students that they can learn mathematics. (10, p. 81-82)

Research has shown that students approach new mathematics problems with some prior knowledge, and then take in new information to form their own concepts. (11, p. 3) Hands-on activities help students understand mathematical concepts and create their own; they learn how to learn as well as learning the important material. (10, pp. 60-61)

**Professional Standards**

Not only are standards required for the mathematics curriculum but professional standards are needed for teachers as well. Very few elementary school teachers have been trained adequately in mathematics. While experts recommend that college students enrolled in a teacher preparatory curriculum take four appropriate mathematics courses, most students are required to take only one class. It is estimated that ten percent or less of America's elementary school teachers meet modern standards for teaching mathematics in the elementary school. (10, p. 28)

The National Council of Teachers of Mathematics has developed guidelines for professional standards for teachers. (9)
Mathematics Teachers

Students at every grade level need to be encouraged to excel in mathematics and to consider mathematics as a career option. Many of those who do choose to continue studying mathematics do not choose teaching. There is a serious shortage of mathematics teachers, and the problem will worsen in the upcoming years. The combination of an increase in the number of students, an increase in the need for mathematics, and the continuing retirements of mathematics teachers will only escalate the shortage of mathematics teachers. (10, pp. 26-27) The demand for qualified mathematics teachers is also felt at the college level, where other mathematics teachers are trained. "Were it not for the large numbers of international students who study and teach in the United States, the state of U.S. mathematics and science would be in total disarray."

(10, p. 26) Our nation—meaning the government, schools, parents, and the general public—desperately needs to encourage the study of mathematics to save the American educational system.

The Attitudes of Students

In order to improve the U.S. mathematics program, students must become interested in mathematics and understand the importance of it. Parents and teachers are very important role models who can influence the value that students place on mathematics. If these role models dislike
mathematics or view it as unimportant, students will adopt the same attitudes. Many students notice the fear of mathematics that is present in the adults around them. "Eventually most students leave mathematics under duress, convinced that only geniuses can learn it."(10, p.44) A student's performance in mathematics is directly related to his or her attitude towards mathematics.(4, p.105) When students become interested in mathematics and put forth effort in their learning, they achieve greater success, thus building self-confidence. Self-confidence, in turn, contributes to heightening interest and developing a more positive attitude, which will be carried into the work force and students' personal lives.(10, p.45)

The Attitudes of the Public

Much is needed and expected from the public to ensure success in improving the mathematics system:

conviction of the need for change; consensus on high-quality mathematics education for everyone; skepticism of "quick fixes" and simplistic solutions; awareness of the general nature of needed changes; support for investment of necessary resources; and recognition of the need for continuing leadership at the national level.(10, p.80)

The public attitude which portrays low expectation in mathematics must be reversed. The support of the public and parents is essential to teachers who work to strengthen school mathematics.(4, p.13) Parents' unwillingness to change hinders the expectations of the NCTM Standards. Peer pressure can also restrict good performance in mathematics,
making it socially unacceptable. Those at the greatest risk, minorities and females, live with the greatest negative expectation. (10, p.10) Many community organizations can reach these at-risk students when school seems uninspiring. (10, p.92) The public must understand the need for change in mathematics education and the inadequacy of today's programs to face the challenges and prepare for success. We, as a nation, must value mathematics education. (10, pp.75-76)

Responsibilities

Everyone has responsibilities in this war against mathematics mediocrity. Students must study mathematics in school and discover it in the world around them. Teachers should evaluate current practices, suggest new ideas, and involve students in their learning. Parents need to demand that schools follow the NCTM Standards, support teachers who strive for improvement, and encourage their children to study mathematics. Principals must keep up with current mathematical issues and support innovation. Superintendents should encourage public discussion of mathematics education and advocate and provide resources for change. School boards need to adopt mathematics standards and evaluation in accordance with the NCTM Standards and promote improvements. Community organizations must provide enrichment activities involving mathematics and involve both students and the public in the coming changes. State school officers should
speak publicly about mathematics education and support the NCTM Standards and elementary mathematics specialists. College and university faculty need to improve the undergraduate program and try teaching methods other than just lecturing. College and university administrators must promote innovation, rely less on part-time, undertrained faculty, and improve teacher education. Business and industry should promote the study of mathematics and science and support education, including funding. State legislators need to work with school leaders and resist simple "cures." Governors must support and provide resources for change and create enrichment programs. Congress should support mathematics education and reward effective efforts. Finally, the president needs to meet with state governors and stress education in Congress and to the public. (10, pp.93-95)

The mathematics education in today's schools must undergo major transitions and restructuring in order to meet the needs of today's children. Mathematics is a key to success in almost every modern-day challenge. Mathematics is all around us, and to function in society, a person must have a strong mathematical background. The purpose of our school systems is to prepare students for the future. Today, the American educational system needs many improvements to meet this challenge. Every U.S. citizen has the responsibility of working to better our schools.
THE STANDARDS

An Overview

In 1986, the Commission of Standards for School Mathematics was established by the National Council of Teachers of Mathematics to advance the improvement of the quality of school mathematics. During the following years, with the input of mathematics educators from across the country, the Commission drafted and revised what is now entitled: Curriculum and Evaluation Standards for School Mathematics. The final version was published in March 1989. This document sets national standards for mathematics curricula in grades K-12 and for the evaluation of curriculum and student achievement. These standards should be used to evaluate the solutions proposed by school staffs, school districts, states, and other groups. (8, p.v) The Standards are guiding the mathematical school reforms of this decade.

The NCTM Standards was written with three goals in mind. The first goal is to show the relationship between young people and mathematics. Children's intellectual, social, and emotional development should be considered when planning a developmentally appropriate curriculum. Learning achieved during the first five years of school lays the foundation for later success. The second goal is to acknowledge the importance of quality learning. Understanding mathematics is much more essential than
memorizing rules and procedures. The third goal relates to children's attitudes. In order to be successful in mathematics, children must know what mathematics is, understand what it means to study mathematics, and view themselves as mathematics learners. (8, p.16)

The Standards were built upon several basic assumptions for three different grade levels--K-4, 5-8, and 9-12. The first assumption for the elementary grades states that "the K-4 curriculum should be conceptually oriented." (8, p.17)

Emphasis on concepts leads to better development of problem solving. Children possess a clearer and better understanding of abstract mathematical concepts when they are based on concrete situations. Relationships should be established between the concepts and procedures. (8, p. 17)

Another important principle is that "the K-4 curriculum should actively involve children in doing mathematics." (8, p.17) The Standards encourage teachers to plan their classroom environments to promote active learning. When writing lesson objectives, teachers need to bear in mind that children are, by nature, active beings. Good active verbs that can be used in planning objectives include: "explore, justify, represent, solve, construct, discuss, use, investigate, describe, develop, and predict." (8, p.17)

Several other assumptions played a key role in the creation of the Standards. Children's ability to think and reason mathematically should be emphasized in the K-4
The application of mathematics should also be emphasized. Children will see a purpose in learning mathematics when applied to real-life situations. These applications should be found in a broad range of content areas within the K-4 curriculum. Learning from the many branches of mathematics not only provides a foundation for future learning, but also shows children how the different branches are interrelated. (8, p.18)

The K-4 curriculum should also incorporate the modern technology of calculators and computers. Calculators help children explore number ideas and patterns, develop concepts, practice problem-solving processes, and apply mathematics in realistic situations. "Calculators do not replace the need to learn basic facts, to compute mentally, or to do reasonable paper-and-pencil computation." (8, p.19) Both methods of calculation, by traditional means and by machine, must be emphasized in today's classrooms. When using calculators, children must be capable of discerning when the calculator is necessary and if their answers are reasonable. (8, p.19) All of these assumptions have been incorporated into the Standards.

Grades K-4 Curriculum Standards

The NCTM Standards expand upon thirteen standards for the K-4 curriculum. The following is a brief summary of each standard.
Standard 1: Mathematics as Problem Solving
In grades K-4, the study of mathematics should emphasize problem solving so that students can--

* use problem-solving approaches to investigate and understand mathematical content;

* formulate problems from everyday and mathematical situations;

* develop and apply strategies to solve a wide variety of problems;

* verify and interpret results with respect to the original problem;

* acquire confidence in using mathematics meaningfully. (S, p.23)

Standard 2: Mathematics as Communication
In grades K-4, the study of mathematics should include numerous opportunities for communication so that students can--

* relate physical materials, pictures, and diagrams to mathematical ideas;

* reflect on and clarify their thinking about mathematical ideas and situations;

* relate their everyday language to mathematical language and symbols;

* realize that representing, discussing, reading, writing, and listening to mathematics are a vital part of learning and using mathematics. (S, p.26)

Standard 3: Mathematics as Reasoning
In grades K-4, the study of mathematics should emphasize reasoning so that students can--

* draw logical conclusions about mathematics;

* use models, known facts, properties, and relationships to explain their thinking;

* justify their answers and solution processes;
* use patterns and relationships to analyze mathematical situations;

* believe that mathematics makes sense. (p. 29)

**Standard 4: Mathematical Connections**
In grades K-4, the study of mathematics should include opportunities to make connections so that students can--

* link conceptual and procedural knowledge;

* relate various representations of concepts or procedures to one another;

* recognize relationships among different topics in mathematics;

* use mathematics in other curriculum areas;

* use mathematics in their daily lives. (p. 32)

**Standard 5: Estimation**
In grades K-4, the curriculum should include estimation so students can--

* explore estimation strategies;

* recognize when an estimate is appropriate;

* determine the reasonableness of results;

* apply estimation in working with quantities, measurement, computation, and problem solving. (p. 36)

**Standard 6: Number Sense and Numeration**
In grades K-4, the mathematics curriculum should include whole number concepts and skills so that students can--

* construct number meanings through real-world experiences and the use of physical materials;

* understand our numeration system by relating counting, grouping and place-value concepts;

* develop number sense;
* interpret the multiple uses of numbers encountered in the real world. (8, p. 38)

**Standard 7: Concepts of Whole Number Operations**
In grades K-4, the mathematics curriculum should include concepts of addition, subtraction, multiplication, and division of whole numbers so that students can--

* develop meaning for the operations by modeling and discussing a rich variety of problem situations;
* relate the mathematical language and symbolism of operations to problem situations and informal language;
* recognize that a wide variety of problem structures can be represented by a single operation;
* develop operation sense. (8, p. 41)

**Standard 8: Whole Number Computation**
In grades K-4, the mathematics curriculum should develop whole number computation so that students can--

* model, explain, and develop reasonable proficiency with basic facts and algorithms;
* use a variety of mental computation and estimation techniques;
* use calculators in appropriate computational situations;
* select and use computation techniques appropriate to specific problems and determine whether the results are reasonable. (8, p. 44)

**Standard 9: Geometry and Spatial Sense**
In grades K-4, the mathematics curriculum should include two- and three-dimensional geometry so that students can--

* describe, model, draw, and classify shapes;
* investigate and predict the results of
combining, subdividing, and changing shapes;
* develop spatial sense;
* relate geometric ideas to number and measurement ideas;
* recognize and appreciate geometry in their world.(8, p.48)

**Standard 10: Measurement**
In grades K-4, the mathematics curriculum should include measurement so that students can--
* understand the attributes of length, capacity, weight, area, volume, time, temperature, and angle;
* develop the process of measuring and concepts related to units of measurement;
* make and use estimates of measurement;
* make and use measurements in problem and everyday situations.(8, p.51)

**Standard 11: Statistics and Probability**
In grades K-4, the mathematics curriculum should include experiences with data analysis and probability so that students can--
* collect, organize, and describe data;
* construct, read, and interpret displays of data;
* formulate and solve problems that involve collecting and analyzing data;
* explore concepts of chance.(8, p.54)

**Standard 12: Fractions and Decimals**
In grades K-4, the mathematics curriculum should include fractions and decimals so that students can--
* develop concepts of fractions, mixed numbers, and decimals;
* develop number sense for fractions and decimals;
* use models to relate fractions to decimals and to find equivalent fractions;

* use models to explore operations on fractions and decimals;

* apply fractions and decimals to problem situations. (S, p.57)

**Standard 13: Patterns and Relationships**

In grades K-4, the mathematics curriculum should include the study of patterns and relationships so that students can--

* recognize, describe, extend, and create a wide variety of patterns;

* represent and describe mathematical relationships;

* explore the use of variables and open sentences to express relationships. (S, p.60)
APPLYING THE STANDARDS

The thirteen standards that are listed and discussed in the Standards are not isolated concepts. The standards are interrelated and are also connected to other mathematical concepts and school subjects. The following are examples taken from elementary mathematics books, the Arithmetic Teacher, and the Standards. These examples apply the first five standards to three of the specific content standards: fractions, geometry, and statistics and probability. These three mathematical content areas were chosen because these concepts many times are neglected in classroom teaching. Since they are placed at the back of elementary mathematics textbooks, teachers often run out of time to teach these subjects. The following examples should show how the concepts of fractions, geometry, and statistics and probability can be connected to other mathematical areas. The first five standards, which include problem solving, communication, reasoning, connections, and estimation, have been applied to these three mathematical areas.

FRACTIONS
Problem Solving:
Children are grouped by fours, with each group receiving paper cookies to share. Begin with 4 cookies to be shared in each group. The children have a sheet on which they glue their parts of the cookies in each group member's box.
Repeat with 6 cookies, and then 5, 3, 2, and 1. Beneath the box on each sheet, the children must answer the question, "How much did each person get?" with the appropriate fraction. (1, pp.37-43)

**Communication:**
Give each student a piece of paper. Ask the children to fold their paper so that they create strips that are the same size, and color some of the parts. The students will then describe to the class what kind of parts they have created, such as fourths, and the numbers of parts that are colored, such as three-fourths. (8, p.57)

**Reasoning:**
Present fraction patterns to the class. An example would be: 1/8, 3/8, 5/8. Use equal-length paper strips with folds to represent fractions. Have students analyze the fraction models to find a pattern, and then add another fraction to the pattern. After several repetitions of this, have students create their own fraction patterns. (8, p.30)

**Connections:**
Have students determine the number of vowels and consonants in class names. They will record on a chart the total number of letters in each name, the number of vowels, the number of consonants, and the fractions representing the vowels and consonants on a chart. This activity can be repeated with children's book titles, spelling words, and so on. (13, p.26-27)
Estimation:
Present three circles labeled: "About 1/2," "About 1," and "About 1 1/2." Have the students estimate and sort addition fraction cards in the appropriate circle. Examples would be: 1/12 + 1/3; 5/8 + 1/2; 4/7 + 7/8. (8, p.58)

GEOMETRY
Problem Solving:
Give the class a collection of shapes and a loop of string. Students take turns choosing a shape and placing it in the loop. The teacher responds with "Yes" or "No," as to whether it fits the sorting rule that the teacher has in mind. During the activity, the children should be thinking of the common characteristics of the accepted shapes. Discuss the results when all the shapes have been choosen. This activity meaningfully defines a shape, such as a parallelogram. (8, p.24)

Communication:
Divide the class into pairs of two. One partner is the giver, and the other is the receiver. The partners sit across from each other with a barrier between them. The giver chooses a card and must verbally describe the shape, such as a square. The receiver must draw a picture of the shape based on the giver's description. When the children finish, have them compare the drawing to the card and
discuss good and poor clues. Trade roles and repeat with another shape. (14, pp.21-23)

**Reasoning:**

The teacher describes a geometric shape to the class and then poses the question, "What am I?" An example would be: "All my angles are equal. My sides are not all equal. What am I?" After the students understand the activity, they can create their own "What am I?" questions to ask the class. (8, p.30)

**Connections:**

Children should better understand the connection between multiplication and geometry, specifically the area of rectangles, by using one inch square tiles. Have children form a rectangle with twelve tiles. List the solutions that the class discovered on the chalkboard. Next, have the children work in groups to explore making rectangles with one to twenty-five tiles. They will record their findings by coloring one-inch square graph paper. Write the numbers 1 to 25 on the board. Under each number, the groups will post their different solutions. This activity also explores patterns in geometry and multiplication. (1, pp.71-84)

**Estimation:**

Give each child a sheet of at least twenty squares with both diagonals drawn. Ask the children to estimate how many different ways they could color this design. Have the students color the designs, but tell them not to count how
many they have colored. After they have finished coloring, have them estimate again how many different designs could be made. Count the designs and discuss which estimation was more accurate and why. Pose another question, "If we could slide, flip or rotate the design, how many different patterns would we have?" Repeat this activity with other shapes. (3, p.120)

STATISTICS AND PROBABILITY

Problem Solving:
Have the students pretend that they are going car shopping. They have a choice of ten exterior colors and four interior colors. Students will make a tree diagram of the possible exterior-interior combinations and analyze it. Ask questions such as: "How many different combinations are possible?"; and "If a person randomly selected a car, what is the probability that the interior would be beige?" Have the students think of other situations in which a tree diagram would be helpful. (5, p.19)

Communication:
Group the children in pairs. Each pair will need a number line from two to twelve, and eleven counters for each child. The children place their counters on the number line. The teacher rolls two dice and the children remove all the counters on that number. The first group to remove all their counters is the winner. Repeat the activity a few
more times and discuss the children's strategies for placing their counters. At the end of the activity have the students describe in writing how they would place their counters the next time they participate in this activity and their reasoning behind their placements. (1, pp. 45-52)

**Reasoning:**
Label four boxes as: "Impossible;" "Unlikely;" "Likely;" and "Certain." Have children sort cards into the most appropriate box. The cards should include statements such as: "It will rain today.;" "Everyone in this room is alive.;" and "There are more righthanded people in this room than lefthanded people." Ask students to explain their reasoning behind their choice of boxes. Then have the students write their own statements to be sorted between the four boxes by the rest of the class. (12, p. 240)

**Connections:**
By exploring statistics and measurement together, children can discover the importance of standard units of measure and the meaning of "middle-sized." Have the students pace the classroom. They will pace, count, gather data, and compare data. The children will soon realize that an accurate measurement cannot be taken when everyone's paces are different sizes. Next, talk about "middle-sized." Ask the students how they would determine "middle-sized." Discuss possibilities such as the middle-sized student, the middle-sized foot, and the middle-sized pace. Have the students
set a standard unit of measure based on "middle-sized" and again measure the classroom. (6, p.36)

Estimation:
Give students a handout with pictures of clowns. Tell the students that they have four choices of hat colors and two choices of mouth colors. Ask the students to estimate the number of possible combinations. Then have them color the possible combinations and compare their estimates. Discuss the probability of randomly selecting a clown that has a red mouth or a yellow hat or some other color. (2, p.31)
CONCLUSION

Great changes are in store for our nation's system of mathematics education. Much improvement is needed, and many people have already joined together to meet the challenges of restructuring the mathematics system. The National Research Council lists four actions that must occur in order to improve U.S. mathematics:

1. Establish new standards for school mathematics.
2. Upgrade the teaching profession.
3. Make assessment responsive to future needs.
4. Strengthen collegiate mathematics.(10, p.95)

Many groups are now working towards these four goals. The first goal is being accomplished by the National Council of Teachers of Mathematics through its creation of the Standards. The National Board for Professional Teaching Standards is upgrading its expectations of teachers. The third goal of improving assessment methods has not yet been confronted to the extent that the other objectives have. To meet this challenge, today's testing programs must be revised and replaced with assessments that will evaluate future needs. Finally, the last goal involving collegiate mathematics is presently being faced by the National Research Council's Committee on the Mathematical Sciences in the Year 2000.(10, p.95)

These changes must progress steadily over the next several years on all levels by all involved. We must not slacken the pace, but at the same time we must not try to
fix our problems too quickly. (10, p.96) Our nation cannot afford setbacks due to lack of planning, organization, or support. If schools, parents, or legislators push for requiring more mathematical courses without any set guidelines or available teachers, then the curriculum would become "watered-down" rather than reaching and setting better and higher standards. If standardized tests were used to evaluate ability and achievement without setting new purposes and understanding them, then the tests would become unreliable and misleading. If test scores would be used more frequently and strictly to set standards without considering other assessments, achievements, or skills, then the tests and standards would act as a barrier to learning instead of encouraging children. (10, p.75) If the planning and implementing of the upcoming changes are thoroughly considered and developed, then failures such as those mentioned above will only be hypothetical. Time is needed for discussion, compromise, and then action.

Teachers will play an important part in implementing the Standards and other essential changes in school mathematics programs. Teachers must be a part of the entire process from development to implementation. Resources and support from school officials, government, and the public will have to be available to assure success. (10, p.91) This success means preparing students for life-long learning and achievement.
Over the next several years the mathematics programs in U.S. elementary schools, secondary schools, and universities will undergo transitions affecting the entire structure of American education. Fundamental changes are needed in curricula, teaching methods, teacher education, textbooks, assessment procedures and purposes, and the attitudes of teachers, school officials, students, parents, government, and the general public. The future mathematics program should prepare all students to succeed in the work force and function efficiently in everyday situations. This will be possible only with support and commitment from all areas of education, government, and the general public. By working cooperatively and with dedication, the goals of the Standards can be achieved and the U.S. mathematics program can be improved to greatly benefit every child and, in turn, our nation as a whole.
BIBLIOGRAPHY


