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AN EVALUATION OF A THIRD GRADE MATHEMATICS PROGRAM USING THE NCTM CURRICULUM AND EVALUATION STANDARDS FOR SCHOOL MATHEMATICS

MASTER'S PROJECT

Submitted to the School of Education

University of Dayton, in Partial Fulfillment

of the Requirements for the Degree

Master of Science in Education

by

Judith E. Comisar

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Dayton, Ohio

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Approved by:

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Jerry L. Neff, Ph.D.

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CHAPTER I

INTRODUCTION

National attention has become critically focused on the need for reform and improvement in education since the 1983 publication of A Nation at Risk by the National Commission on Excellence in Education. This call for reform was also echoed in the National Science Board's Educating Americans for the 21st Century and the Conference Board of the Mathematic Sciences' publication What Is Fundamental and What Is Not. In all these works, deficiencies in our school mathematics programs were particularly under scrutiny. In our ever changing global technological society, current mathematical achievement of U.S. students is nowhere near what is required to make our nation a leader.

The documented need for a quality mathematics education for all is overwhelming. Our technological world has "mathematized" the workplace (National Research Council, 1989) with not just a need for calculation but for an ability to absorb new ideas, to perceive patterns, to solve complex problems, to work cooperatively and to think mathematically. Despite all this, America has settled for underachievement as the norm for mathematics education. As stated in Everybody Counts, " We have inherited a mathematics curriculum conforming to the past, blind to the future, and bound by a tradition of minimum expectations" (National Research Council,

1989). Our young students today will graduate in the 21st century, yet most are experiencing a narrow computationally driven math curriculum with rote memorization of facts and algorithms and limited exposure to a wide variety of problem solving situations. Furthermore, studies reveal that three-fourths of our students leave school without sufficient mathematics preparation for the problem solving demands of many jobs or for the mathematical literacy requirements of colleges. As a result businesses are having to spend billions of dollars each year to train workers because the schools have not. MIT economist Lester Thurow asks "How can students compete in a mathematical society when they leave school knowing so little math?" (Thurow as cited in Everybody Counts, p. 1). All of this, along with comparatively low standardized mathematic assessment test scores, gives ample reason for concern.

The National Council of Teachers of Mathematics (NCTM) has responded to the call for reform by creating in 1989 a monumental document, Curriculum and Evaluation Standards for School Mathematics, which contains definitive statements about what they feel should be valued in mathematics education. The Standards represent a major shift in emphasis from current programs dominated by students as passive participants and teachers as transmitters of knowledge to new broad curriculums with students as active participants in constructing mathematic ideas through exploring, investigating, discussing, reasoning and problem solving and with teachers as facilitators of learning.

There is widespread support and endorsement for these Standards, from professional organizations such as the National

Council of Supervisors of Mathematics and the American Association of School Administrators to allied groups such as the American Bankers Association, the Joint Council of Economic Education and the Children's Television Workshop. Despite this nation wide attention, a recent teachers' journal indicates that the vast majority of elementary school teachers are not even aware of the Standards (Hitch, 1990). When teachers are informed about the changes being recommended by the NCTM, they are often very resistant to changing the way they have been teaching math to their students. From this it is evident that there is not only a need to educate teachers about the Standards but also to involve teachers in a pioneering effort to get other teachers to work to achieve these new objectives that can help their students learn math more effectively.

Reason for doing the project

During the last two years this writer has become interested in and more acutely aware of the need for changes in our school mathematics program as a result of an involvement in an in-depth math workshop "Taking Math in Stride" led by elementary math consultant Clare Clark. She has authored Math in Stride, an activity-based developmental math program that contains many of the approaches described in the NCTM Standards. Clark's explanation of the Standards during this workshop was this writers first encounter with this important document that is currently the basis for change and re-evaluation of all school mathematics in the United

States. The information and materials derived from this workshop experience have led this writer to a feeling of dissatisfaction with the math program and methods that were being used in her own third grade classroom. After implementing some of the ideas and materials of the Math in Stride program, there developed for this writer an increasing awareness of the conflicts and shortcomings that exist in much of the traditional math curriculum and teaching methodologies as compared to those set forth in the Standards.

Goal:

To study and understand the Standards and to use them as a basis for evaluating our existing math program are the goal of this project. The objectives are (1) to list the curriculum standards appropriate for grade level three, (2) to evaluate the inclusion of each of these standards in the various components of the third grade math program which includes the district math curriculum, the Pupil Performance Objectives or PPO's, the Iowa Test of Basic Skills or ITBS, and the adopted text which is Addison-Wesley Mathematics, copyright 1991, and (3) to make a value judgment about the extent to which each component is in alignment with the NCTM Curriculum Standards for grades K-4. The results may be helpful to this writer and may also be of assistance to colleagues as we move to change and improve our own school mathematics program.

Scope of the project

To delimit the scope of the project, this writer has focused her evaluation on only the third grade mathematics program. In the Standards there are thirteen curriculum standards for grades K-4 that have been reviewed; the content of each one has been used to help evaluate the previously mentioned components of the current third grade math program.

Assumptions

What math is taught in the classroom and how it is taught are strongly influenced by a school district's curriculum and adopted materials. This writer assumed that the existing third grade math program contains the various components to be evaluated, i.e. the district math curriculum's program goals and math objectives, the third grade pupil performance objectives, the adopted textbook and accompanying support materials, and a standardized achievement assessment test.

It was further assumed that the 1989 NCTM Standards contain the latest and best vision of what a high quality mathematics program for all students should be.

Limitations

This evaluation is limited to one third grade in one elementary school in a small suburban school district. It is a community of college educated parents with a high socio-economic base. The evaluation has been carried out during a school year.

Definition of terms

Key terms that must be defined for clarification and understanding of this project include the following, as found in the NCTM's Standards (1989).

Curriculum - A curriculum is an operational plan for instruction that details 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 context in which learning and teaching occur. This might be labeled the "intended curriculum".

Evaluation - An evaluation is a measure for gathering information on which teachers can base subsequent instruction. In this project the information is about the curricular program.

Standard - A standard is a statement that can be used to judge the quality of a math curriculum or methods of evaluation. Standards are statements about what is valued.

Mathematical literacy - Mathematical literacy is the ability to cope confidently with the mathematical demands of adult life, that is to

understand basic mathematical ideas and grasp implications of concepts such as chance, logic, graphs, and probability. The British use the term "numeracy".

Alignment - alignment refers to the agreement of the component being assessed with respect to the curriculum standards.

CHAPTER II

LITERATURE REVIEW

There is an abundance of literature and research to substantiate the problems, conflicts and need for change in mathematics education. The problem is a multi-faceted one, ranging from the psychology of learning, to the demands and attitudes of society, to misplaced priorities of educators and legislators, to curriculum and teacher effectiveness and classroom environment.

Because of the growing number of applications of mathematics in our world today, mathematics is second only to English as the most widely studied subject in school. Our technological world of the 20th century that has "mathematized" our workplace calls for more math for our students not less. "Today's world is more mathematical then yesterday's, and tomorrow's world will be more mathematical than today's" (Everybody Counts, 1989). With the phenomenal impact and growing power of computers has come the mistaken belief on the part of many people that the need for mathematics will decline. While computers and calculators may lessen the need for arithmetic proficiency, the pervasive role of computers in science and society contribute to an increased role for mathematical ideas, ideas that play an important role in decision making at home, at school and on the job (Everybody Counts, 1989).

One of the key themes that is repeated in many of the recent studies of mathematics education is that of attitude and minimum expectations. "We've inherited a woefully limited set of

expectations of what schools can accomplish and what children can learn" (William Graham as cited in Everybody Counts, 1989). Much of the American public assumes that differences in mathematical accomplishments are due to differences in innate ability of students rather than to differences in student effort or in opportunities to learn. Oftentimes parents' attitudes and offhand remarks such as "I was never very good at math" or "I hated math" may lower their own expectations of how well their children should perform in mathematics. Many adults with meager or limited math backgrounds who have managed to succeed without it rationalize that expectations can be maintained at a minimum basic level. Adults' unpleasant childhood school experiences in mathematics contributes to this socially acceptable attitude of lowered expectation. "Children can succeed in mathematics. If more is expected, more will be achieved," says the National Research Council in Everybody Counts. We know that many children do succeed in other countries as do some in our own country. Evidence from other countries such as Japan overwhelmingly shows that if more is expected in mathematics education, more will be achieved if only students work hard enough. If in our schools, teachers and parents value and promote the idea that hard work and effort by our students will be rewarded and that success in mathematics is expected and desirable, our students will respond with more positive efforts and results.

Research tells us that virtually all young children like mathematics. For them, math is a way of making sense out of things - perceiving patterns, reasoning, and comprehending data. Young

children are inventive mathematical thinkers, having strategies for problem solving which are more efficient and conceptually based than the mechanical procedures they are taught in school (Romberg and Carpenter, 1986, as cited in Desforges and Cockburn, 1987). As children become socialized by school and society, they unfortunately begin to view mathematics as "a rigid system of externally dictated rules governed by standards of accuracy, speed and memory" (Everybody Counts, 1989). Math anxiety and apprehension takes over for many students, and they then grow up with a feeling that only the math whiz kids can learn it. This attitude and conviction may carry over into their adult roles as parents or even as teachers who then inadvertently convey this attitude to students. Reversing these kinds of attitudes and anxieties is one of the challenges that face school mathematics educators.

Traditionally most school mathematical curricula seems to have placed more emphasis on memorization of facts and algorithms and on one right answer rather than on reasoning or problem solving (Romberg and Carpenter, 1986, as cited in Congelosi, 1988). Checklists of skills for each grade level define for the teacher what is important, this is what children should be able to do. The assumption has been that if children are learning the skills on the checklist, then all is well. This carries over to the great concern about performance on standardized achievement tests as a measure of how well our students are doing. Frustrations over declining test scores in recent years have resulted in parent and legislative pressures that have in turn led to increased use and misuse of standardized tests with little understanding of what they are

capable of testing or measuring. Using test scores for teacher and school accountability often results in lower morale and watered down curricula that contains little or no emphasis on higher order thinking skills.

Much of the bad press that has been leveled at our school mathematics education has been aimed at the teachers of mathematics. While new studies and research have identified problems and recommended new methodologies and teaching materials that should assure success, many critics assume that it is teachers' conservative attitudes and their poorly informed practices that are to blame for keeping children from successfully experiencing all these wonderful new mathematical ideals (Desforges and Cockburn, 1987). Researchers Desforges and Cockburn (1987) maintain that this is not the case; rather they believe that classroom working conditions and processes, the unpredictable nature of the classroom environment and the diversity of the children's states of knowledge all impinge on teachers as they endeavor to implement many aspects of the mathematics programs. Furthermore, these researchers point out that mathematics educational literature as well as the public do not understand the complexities of the teachers' task. Teaching mathematics effectively is in itself a difficult job. The challenge then is for researchers to collaborate with teachers and administrators to change and improve both materials and conditions under which teachers must teach (Desforges and Cockburn, 1987).

Mathematics educator, James Congelosi has written extensively on classroom management strategies for teaching

mathematics and on developing ways to give mathematics real-life meaning for children. He advocates the use of language activities that will integrate math curriculum with the curricula of other school disciplines such as science and social studies, and he encourages teachers to build on students' personal experiences by applying mathematical concepts to real life problems, designing learning activities that will require students to write or speak about mathematics (Cangelosi, 1988). These kinds of nontraditional math activities fit very nicely with the new key themes and emphasis that are addressed in the NCTM Standards.

"Essential Mathematics for the Twenty-first Century" is a position statement by the National Council of Supervisors of Mathematics (NCSM) (1989) that states their views regarding "essential mathematics" for students. The NCSM concludes that essential mathematics represents the mathematical competence students will need for responsible adulthood. Twelve critical areas of mathematical competence for students are identified and all twelve are interrelated. These twelve areas and the thirteen curriculum standards from the NCTM Standards which are to be the focus of this evaluation project both have the same goals for mathematics education and for all students. These goals are for students to value mathematics, to become confident in their ability to do mathematics, to become mathematical problem solvers, and to communicate and reason mathematically ("Essential Mathematics", 1989)

The NCTM Standards project is "a blueprint for a design change, not a bandage to patch up deficits here and there", according

to Thomas Romberg, the chairman of the Commission on Standards for School Mathematics (Romberg as cited in Crosswhite, Dossey and Frye, 1989). These vital changes cannot be brought about by administrative edict or by minor adjustments to the curriculum. These changes can only be affected through commitment of the people involved in delivery of instruction, namely the teachers.

Teachers who understand and recognize the importance and necessity of changing and reforming traditional math curriculum and methodology and of implementing the new Standards need to band together to achieve support for each other. It should be a gradual process wherein teachers unobtrusively implement the Standards, sharing ideas with like-minded colleagues (Hitch, 1990). One teacher working alone is not going to be able to generate any ground swell of support for revising the way teachers have taught for many years. Building coalitions of teachers interested in implementing the Standards and then promoting in-service opportunities and course work to help train and develop within teachers a comfort level with the new materials and methodologies are important steps. As the teachers gain in confidence and experience success with innovative math programs, they need to share these successes as credible evidence that the Standards can be realized. According to Hitch (1990), it is also important that these teachers reassure other colleagues and parents that the Standards have received the full support of key national educational organizations as well as national and state Parent Teacher Organizations.

From the studies and research cited, it is clear that there is a growing need for essential mathematical literacy for all students

in the twenty-first century and that there exist problems and needs for change and reform in our schools' mathematics education programs. The mathematics education community has responded with studies, position statements and Standards that address these needs and reflect a commitment to affecting the changes that are essential to provide our young people with the mathematical competencies that will meet the demands of an increasingly technological world.

CHAPTER III

METHODOLOGY

What mathematics is taught in the classroom and how it is taught are strongly influenced by a district's curriculum, adopted materials, and testing programs. A necessary first step in determining the extent to which a math program meets the Standards is to examine the current program. In this project, the writer has evaluated the existing math program in her third grade classroom in order to ascertain those elements of the program that support and implement the thirteen Curriculum Standards for Grades K-4 that are outlined in the 1989 NCTM Curriculum and Evaluation Standards for School Mathematics and those that do not. It is important to note that these thirteen standards relate to the NCTM's instructional plan. There are additional evaluation standards that address the ways in which students integrate connections among concepts, procedures and intellectual methods to help them develop mathematical power.

Four components of the existing math program have been evaluated: (1) the third grade math curriculum, its goals and objectives as outlined in our district's course of study; (2) the third grade pupil performance objectives; (3) the mathematics sections of the Iowa Test of Basic Skills, level 9, which is the standardized assessment test currently being used; and (4) the newly adopted Addison-Wesley Mathematics 1991 textbook and support materials.

Each of these components has been examined from the perspective of thirteen curriculum standards for grades K-4 that are outlined in the NCTM's Curriculum and Evaluation Standards for School Mathematics. To do this a matrix was developed on which each of the thirteen standards for grades K-4 was summarized. Each of the four components of the existing program was evaluated and rated on a scale of 0 - 3. This scale was devised to give this writer some uniform means of interpreting what is a very subjective evaluation of the math program. On this scale, the writer used 0, 1, 2, and 3 with these interpretations: a zero (0) rating indicates no evidence of inclusion of the particular standard in the component being evaluated; a one (1) rating indicates limited evidence of inclusion of the standard; a two (2) rating indicates a significant amount of inclusion of the standard; a three (3) rating indicates strong evidence of inclusion of the standard. Using these ratings the writer recorded on the matrix the degree to which each component in the math program supports or is in alignment with the suggested content in the thirteen K-4 curriculum standards. Elements in the four components that did not fit in or support any part of a standard were given a "0" rating. A final analysis of the ratings on the matrix for each of the four components of the existing program indicates the degree to which each component of the program is consistent with the Standards. This also has enabled the writer to determine which standards are not being addressed or covered by any part of the current math program.

The evaluation was done during the second half of the 1991-92 school year and was based on the math program that was used during

that school year. The results of this evaluation have helped this writer suggest recommendations for changes and improvements in the third grade math program to more effectively implement the reforms and goals inherent in the new Standards . These changes will better serve the needs of all students both now and in the future.

MATRIX

CURRICULUM STANDARDS FOR K-4	DISTRICT MATH CURRICULUM	GRADE 3 PPO'S	IOWA TEST OF BASIC SKILLS	TEXTBOOK
1. PROBLEM SOLVING	1	1	1	2
2. COMMUNICATION	0	0	0	2
3. REASONING	1	1	1	2
4. CONNECTIONS	1	0	0	2
5. ESTIMATION	1	1	1	2
6. NUMBER SENSE & NUMERATION	1	1	1	2
7. CONCEPTS OF WHOLE NUMBER OPERATIONS	1	1	1	2
8. WHOLE NUMBER COMPUTATION	2	2	2	2
9. GEOMETRY & SPATIAL SENSE	1	1	1	2
10. MEASUREMENT	2	2	1	2
11. STATISTICS & PROBABILITY	1	0	0	2
12. FRACTIONS & DECIMALS	1	1	1	2
13. PATTERNS & RELATIONSHIPS	0	0	1	2

CHAPTER IV

FINDINGS

The findings that have resulted from this evaluation of the existing third grade math program have been recorded on the matrix that appears on the previous page. On this matrix the thirteen standards deemed appropriate for grades K-4 have been listed and identified. A more detailed summary of what each of these curriculum standards should include and emphasize according to the National Council of Teachers of Mathematics is contained in the appendix. The four components of the existing third grade math program which have been evaluated are listed horizontally across the page. In each square on the matrix below, this writer has recorded a number (0, 1, 2, or 3) to indicate her judgment as to the degree of inclusion of the elements contained in the K-4 standards for each of the four components of the existing third grade math program. A zero (0) indicates no evidence of inclusion of the standard in that particular component, a one (1) indicates limited evidence of inclusion, a two (2) indicates a significant amount of inclusion, and a three (3) indicates strong evidence of inclusion. These findings as recorded on the matrix are a totally subjective composite of this writer's evaluation of the existing third grade math program.

Curriculum

In looking at the district's curriculum goals and objectives for grade three, there are several findings that this writer found to be significant. For most of the standards, there is at least limited evidence of inclusion of the standards included in the district's third grade curriculum. As a result, nine of the thirteen standards for this component have been rated with a one (1).

Two standards that are not addressed in any discernible way in the existing district curriculum are Standard #2 , "Mathematics as Communication", and Standard #13, "Patterns and Relationships". The communications standard stresses the importance of helping children to clarify their thinking and to sharpen their understandings by representing, talking, discussing, reading, writing and listening. These vital ideas seem to go beyond the scope of any of the goals and objectives stated in the district curriculum. The intent of Standard #13 is for students to relate their math discoveries to the patterns and relationships that exist in the world around them and to encourage the student to look for and identify patterns in numbers, in geometric shapes and objects and in measurements, to recognize relationships and to make connections. Again there is no evidence of these ideas in the stated goals and objectives of the existing curriculum.

As the findings on the matrix suggest, there are two standards for which there seem to be a significant amount of inclusion in the district's third grade curriculum. These are Standard #8, "Whole Number Computation", and Standard #10, "Measurement". The goals

of the district's third grade curriculum emphasize computation skills heavily; indeed, knowing and applying these skills is the predominant thrust of this curriculum. It is written in the student objectives to "know and apply", "use", "identify and write", "recognize and use" the various numbers, facts and algorithms to be taught in grade three. Similarly many of the elements suggested in Standard #10 relating to measurement are in evidence in the district's curriculum objectives; these direct the student to use and apply measurement skills relating to time, temperature, weight, length, area, volume and geometric angles.

Pupil Performance Objectives

In this writer's evaluation of the existing third grade Pupil Performance Objectives or PPO's as they relate to the thirteen curriculum standards for grades K-4, the findings are very similar to those for the curriculum component. The PPO's include more significant amounts of the whole number computation and measurement elements that are part of Standards #8 and #10 than anything else that is suggested in the thirteen standards. Specifically ten out of twelve grade three PPO's can be related to the content in these two standards. In that these are performance objectives for students, they are concerned with the student's ability to accomplish or perform specific number and measurement skills or tasks. Like the curriculum component, the PPO's also do not show evidence of inclusion of Standard #2, "Communications", or Standard #13, "Patterns and Relationships". Nor is there any

objective in the list of PPO's that supports or relates to Standard #4 which stresses the importance of opportunities to make mathematical connections or to Standard #11 which deals with exploring statistics and probability.

Standardized Test

The standardized assessment test component of the grade three math program is contained in the Iowa Test of Basic Skills, Level 9, Form G. There are three parts in this math assessment test, one for math concepts, the second on problem solving, and the third on computation. To summarize the significant findings following this writer's evaluation of the contents of the ITBS, many parallels can be drawn to the findings for the curriculum and PPO components. Like those components, the ITBS has a significant amount of whole number computation as tested in Test M3 Computation. This tests proficiency with basic facts and algorithms. As with the other components, this writer found limited inclusion in the ITBS of seven of the other thirteen standards. It seems significant to note the one (1) rating for Standard #1, "Problem Solving"; even though one entire section of this assessment test is devoted to problem solving, this writer found these problems to be largely one step, one dimensional problems that do not require the higher level thinking skills and varied approaches and strategies that are emphasized in Standard #1. This test of basic skills shows no evidence of the elements in Standard #2, "Communications", Standard #4,

"Mathematical Connections", or Standard #11, "Statistics and Probability".

Textbook

The fourth component of the existing third grade math program that was evaluated in this project was the textbook, Addison-Wesley Mathematics, copyright 1991, and its support material. This new edition has been specifically reworked to implement the requirements of the NCTM Standards. The consistent two (2) ratings on the matrix reflect this writer's findings that this text does in fact contain a significant amount of inclusion of the content and emphases that the thirteen K-4 curriculum standards address. When this writer compared this 1991 Addison-Wesley text to a 1985 edition which had been in use prior to this school year, it was apparent that the new text contains much of the same content presented in the same sequence. However, the lesson development and varied approaches and applications which have been added to implement the standards offer more variety and interest both for students and teachers if these new ideas are utilized. For example, there is a short "try it out" exercise followed by more practice; each lesson continues with a short application section with a problem solving and reasoning activity and sometimes mental math or an estimation problem. These items are clearly designed to implement some of the important standards.

It is significant to note that several of the standards that are either missing or found only to a limited degree in the other

components of the third grade math program are much more in evidence in this textbook program. Among the most notable are Standard #2, "Communication", Standard #4, "Mathematical Connections", and Standard # 11, "Statistics and Probability".

Standard #2, "Mathematics as Communication", recognizes the importance of developing children's ability to talk about mathematics and to relate mathematical ideas to their daily lives. Accordingly the lessons in the text provide motivational strategies that offer students ideas to explore and discuss. After talking about these ideas, there are opportunities to predict outcomes using new information from the lesson. This communication standard highlights the need to involve children in actively "doing" mathematics which then leads to their talking about it. To this end the textbook writers have inserted different types of learning activities using a variety of manipulative materials, some of which are included with the support materials for this textbook in the form of a manipulative kit. This kit contains place value blocks, two color counters, cube-a-links, fraction circles, a geoboard model, number cubes, spinners and play money. In utilizing these materials, students are encouraged to explore, investigate, describe and explain a mathematical problem or idea. All of this promotes communication which in turn helps students clarify their thinking about these mathematical ideas or situations. Along with this "doing" math, many lessons give suggestions for small group or cooperative learning activities that stimulate communication. Children are thus encouraged to discuss and explain their mathematical experiences.

Standard #4 addresses opportunities for making mathematical connections. To this end, the Addison-Wesley text offers teachers connection ideas in each lesson, showing ways to use math in daily life situations and in other curriculum areas. Each lesson has a problem of the day idea and a subject integration suggestion as well as a math or life skill connection. If these are utilized by the teacher, students are exposed to a variety of ways to connect their math learning to other situations or subjects. Thus mathematics as presented in this textbook is not just a collection of isolated topics that have no relationship to other topics. Applying mathematical knowledge of money, fractions, geometric forms and measurement are some of the ways students are encouraged to make these connections and to use math in their daily lives.

Standard #11 stresses the importance of understanding statistics and probability in a modern technological society. Students need to be able to collect, organize and describe or interpret data, using graphs and charts or displaying and organizing objects. The new text has addressed this standard by adding an entire chapter on data, graphs and probability, topics that were not included in the earlier Addison-Wesley text. In this chapter students learn how to read and make bar and picture graphs and how to collect and analyze data by using it in group decision making situations. There is an introduction to probability, relating chance to games, sports or contests. Spinners from the manipulative kit are utilized; students can "connect" this probability device to real life games in which spinners are used. Students become involved in mathematical reasoning as they learn to read line graphs and make

predictions using the direction of change on the line graphs. In these activities students also utilize the emphasis in Standard #2 and #4 as they communicate and make many mathematical connections.

It also seems significant to note that Standard #1, "Problem Solving", which the Standards maintain should be the central focus of a mathematics curriculum, receives high marks in this evaluation of the textbook component of the third grade math program. In addition to offering numerous complete lessons on problem solving, this strand is incorporated in every lesson by the inclusion of at least one problem solving exercise in the application section of the lesson. The idea of building a repertoire of varied problem solving strategies is also well developed in this text. Thus problem solving becomes a part of the math instruction on a regular basis and is not treated as an isolated topic.

This textbook offers a good balance of supplemental worksheets to serve the varied student abilities and needs within a classroom. Along with regular practice supplements, there are reteaching pages for those who need extra reinforcement and challenges and thinking skill exercises to be used as an extension for more capable students.

The findings as recorded on the matrix and discussed in this chapter reflect, in the judgment of this writer, the degree to which the four components of the existing third grade math program show evidence of inclusion of the Curriculum Standards for Grades K-4 as outlined in the document, Curriculum and Evaluation Standards for School Mathematics.

CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

To study and understand the NCTM Standards and to use them as a basis for evaluating an existing third grade math program has been the goal of this project. Extensive review of professional literature and research about the problems, conflicts and the need for change in mathematics education confirmed an earlier concern and interest in this critical educational issue following this writer's participation in an in-depth math workshop during the summer of 1990. It was during this workshop experience that this writer first became aware of the new NCTM Standards, learned about activity-based developmental math approaches, and began to understand the implication for all school mathematics programs. The frustrations and conflicts that were encountered as this writer began to implement some of the ideas and materials derived from the workshop brought into focus the original problem and reason for doing this project.

To proceed with this project, the following objectives were set forth: (1) to list from the NCTM Standards the curriculum standards appropriate for grade three; (2) to evaluate the inclusion of each of these standards in the various components of the third grade math program; and (3) to make a value judgment about the extent to which each component is in alignment with the NCTM Standards as outlined for grades K-4. These results were recorded

on a matrix, using a rating scale of 0 - 3, as described in Chapter III, to interpret this value judgment.

The findings as recorded on the matrix and reported in Chapter IV have led this writer to determine the degree to which the components in the existing math program support the suggested content in the thirteen K-4 curriculum standards. The findings in this evaluation have also led this writer to draw various conclusions and to suggest recommendations for change and improvement in the existing math program.

Conclusions and Recommendations

From the ratings on the matrix, this writer has concluded that the contents of three of the four components that have been evaluated are to a great extent not in alignment with the NCTM Standards as outlined in the Curriculum Standards for Grades K-4. The district's curriculum goals and objectives for grade three, the PPO's for grade three, and the items on the ITBS standardized test contain for the most part only limited or no evidence of inclusion of the elements in the standards for grades K-4.

The one exception relates to Standard #8, "Whole Number Computation", which includes "developing reasonable proficiency with basic facts and algorithms". For this one item, a more significant amount of inclusion was found in all three components. Since the goals and objectives of the district's math curriculum and the PPO's have a heavy emphasis on computational skills, this finding is not surprising. However, with regard to Standard #8, it

must be noted that it addresses the importance of rethinking how computation is done in our technological age when calculators and computers do almost all complex calculating. This standard also stresses the importance of teaching children a variety of ways to compute including mental math and estimation techniques, using calculators appropriately, and emphasis on building understanding of underlying concepts through the use of manipulatives and models. This is a developmental approach to computation that helps children develop thinking strategies for learning facts and algorithms, not the traditional rote memorization. So while there appears to be a more significant amount of inclusion of this computational standard in the curriculum, PPO's and ITBS components, this writer suggests that the approach and emphasis be reworked to be more closely aligned with the intent of the computation standard.

Looking specifically at the district's math curriculum, there is some language in the statement of philosophy and goals that seems compatible and supportive of the Standards. The philosophy views mathematics as a tool for communicating quantative and spatial ideas; it seeks to provide a creative mathematical environment in which students will develop self- confidence and gain adequate mathematical knowledge in order "to become functioning members of a rapidly changing society". This philosophy is compatible with the Standards' vision for school mathematics built around curricular goals for a student to learn to value mathematics, to become confident in one's own ability , to learn to communicate mathematically, to reason, and to become mathematical problem solvers.

Even though some of the language in the philosophy and goals of the district's math curriculum seem in alignment with the standards, there remains a need for a basic restructuring of the curriculum to build one that is based upon the elements in the curriculum standards. It would be the recommendation of this writer to work with groups of interested teachers to first educate them about the NCTM Standards, its content and its vision of what a school mathematics program should be. Once teachers have an understanding of this and are convinced about the need for and direction of change, they will be ready to work together to determine appropriate content and supportive instructional approaches.

With regard to the PPO's the writer must conclude that by virtue of the language alone, there is not alignment between the PPO's and the curriculum standards. The PPO component relates to performance objectives and to measuring performance of particular math skills. What the curriculum standards contain is not measurable in the same way; rather the curriculum standards want to develop students who can "understand", "develop", "realize", "relate", "believe", "verify", "acquire", "investigate", "formulate", "interpret", "model", or "explain" mathematics while the PPO's require that students can "tell", "recall", "find and compare", or "add, subtract, multiply and divide". These objectives are very different and imply totally different teaching approaches. Like the curriculum, the PPO's need to be reworked to reflect the content of the curriculum standards. Changes to improve the content of the PPO's must follow changes in the curriculum itself. Again these

changes will be effected only when teachers and administrators come to an understanding and acceptance of the nature of and strategy for change that the Standards require.

Just as the PPO's have language and outcomes that are not aligned with the language and outcomes addressed by the curriculum standards, the standardized testing component, the Iowa Test of Basic Skills, does not measure or evaluate the same kinds of student abilities that the curriculum standards would require. The ITBS testing component that was evaluated in this project assesses specific math concepts, computational skills and largely one step problem solutions; the ITBS does not assess the student's ability to think about a problem, to reason, to communicate or to apply mathematical knowledge, all elements that are implied in the curriculum standards. Because school systems and staffs are required to use and make public the results of such standardized tests as a measure of students' skills as well as of the school's effectiveness, administrators and teachers continue to feel a need to teach to the test. Much of this kind of instruction is counter to the curriculum objectives in the Standards. Assessments, according to the Standards, need to be an integral part of teaching to include assessing what students know and how they think about mathematics; this needs to be done through teacher observation not just by counting correct answers on an answer sheet as the standardized test component does. For these reasons, the writer concludes that the standardized testing component evaluated in this project is not in alignment with the curriculum standards for grades

K-4. However, it is not in the realm of school district policy makers to make any changes in this testing instrument. The only recommendation that seems feasible is to rethink the importance and emphasis that is currently placed upon these test results as indicators of student achievement and program outcomes.

As stated in the findings, the one component in this evaluation that is most closely in alignment with the elements contained in the K-4 curriculum standards is the newly adopted Addison-Wesley textbook which has been specifically revised to implement the NCTM Standards. This text has support materials, abundant problem solving activities and suggested mathematical connections to be used; these all have been integrated into the textbook approach to provide varied methods of instruction that will address in some ways each of the thirteen K-4 curriculum standards. The writer concludes that this improved text is a big step in the right direction. It has been the experience of this writer after using this text for the first year that there is more material in it than can possibly be utilized in the time available to teach. It is therefore incumbent upon the teacher to be selective in utilizing those parts of the program that will most effectively serve the students. What needs to happen in order for teacher to make these judgments wisely is to provide comprehensive in-service training on the use of these new materials; another prerequisite is to provide more time for teachers to study and plan the best use of the selected materials.

Even with this improved text there are still many changes that need to be addressed in order to restructure the mathematics program to implement that which is envisioned in the Standards.

The textbook is only one component of the program and as such, it should not drive the curriculum. The Standards want students to use other materials to explore, to investigate, to discover and to model. Teachers need to understand this and act as facilitators to provide the extra materials and opportunities for this exploration. This writer has had the opportunity to incorporate some of these kinds of supplemental materials and activities into her classroom math program as a result of workshop training and exposure to an activity-based developmental math program. This supplement to the regular math curriculum is not an official part of the current third grade math program and therefore was not included as one of the components to be evaluated on the matrix. The activities have been used selectively as time permits. It is significant to note that these activities and approaches strongly support many of the elements in the thirteen K-4 curriculum standards. For example pattern blocks and tangrams are used to solve problems, to develop spatial sense and to find geometric relationships. Color tiles and attribute blocks help students understand patterns and relationships. Communicating about these discoveries is another outgrowth of these activities and is supportive of an important standard. Mathematical reasoning and estimation strategies are also involved in many of these activities. Student have been introduced to multiplication and division facts and concepts by drawing and counting arrays and then writing facts about their findings rather than simply memorizing the facts. All of these math activities involve the student in "doing" mathematics. It has been the observation of this writer that students are eager participants;

they enjoy this active math and learn through discovery, investigation and manipulation of concrete objects. From this experience, it is highly recommended that these kinds of supplemental math activities and materials become part of the regular math program. Again, it is only when teachers receive adequate training and become convinced of the importance and value of these kinds of math activities that they will feel comfortable and ready to use them in their classrooms.

If all of these recommendations for change and improvement are to come to fruition, it will take not only staff education and training about the Standards and their content, it will take time, time to bring about the changes and time to implement them in our curriculum and in our classrooms. One of the greatest frustrations for this writer has been the problem of not having enough of the larger blocks of time necessary to carry out these new activity-based approaches to math. Therefore, another important recommendation is that teachers be given the flexibility to allot a greater amount of time in each day for math instruction and exploration. At least one hour in each school day is needed to begin to implement these new ideas and approaches. Knowing of the need to follow State guidelines about time allotments in each curriculum area, this may not seem possible. But as teachers become more familiar with the new programs and ideas, they will find ways to connect mathematics to other curriculum areas. In doing this, teachers would be reinforcing the important concept that mathematics is part of and related to many aspects of our daily lives.

Summation

Based on the NCTM Standards and a subjective evaluation of the existing third grade math program consisting of the district's math curriculum, the Pupil Performance Objectives, the Iowa Test of Basic Skills, and the Addison-Wesley Mathematics, 1991 textbook, the following professional recommendations are concluded: (1) to make all teachers of mathematics aware of the contents in the NCTM Standards; (2) to revise district math curriculum and PPO's to address the Standards; (3) to rethink the emphasis placed upon the results of standardized tests as a measure of student achievement and program outcomes; (4) to provide comprehensive in-service training for teachers to assist them in implementing the Standards and new teaching approaches; (5) to make the use of supplemental activities and manipulative materials part of the regular math program.

Having concluded this study of the NCTM Standards and the evaluation of an existing math program based on new curriculum standards, this writer firmly believes that the NCTM Standards provides the blueprint for a complete change in the content of our mathematics curriculum and in our approach to instruction and delivery of the content. These changes will require resources, time, training and commitment on the part of school communities and educators, but these changes and improvements will ultimately benefit our students and the society in which they will one day work and direct their energies.

APPENDIX

The following is a summary of the curriculum standards for grades K-4 excerpted from the Curriculum and Evaluation Standards for School Mathematics, pages 23-60, published in 1989 by the National Council of Teachers of Mathematics, Reston, VA.

CURRICULUM STANDARDS FOR GRADES K-4

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.

Standard 2: Mathematics as Communications
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.

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 ansawers and solution processes;
- -use patterns and relationships to analyze mathematical situations;
- -believe that mathematics makes sense.

Standard 4: Mathematical Connections
in grades K-4, the study of mathematics shoul 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.

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, measurements, computation, and problem solving.

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.

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.

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.

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.

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;
- -development the process of measuring and concepts related to units of measurement;
- -make and use estimates of measuirement;
- -make and use measurements in problem and everyday situations.

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.

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 fraction 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.

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.

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