Integrating mathematics in the primary classroom

Nancy Jean Baker

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INTEGRATING MATHEMATICS IN THE
PRIMARY CLASSROOM

A Project
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Masters of Arts
in
Education: Elementary

by
Nancy Jean Baker
March 1994
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PRIMARY CLASSROOM

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Approved by:

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ABSTRACT

As society moves from the industrial age to the informational age, new educational goals must be made which prepares today's students for tomorrow's world. Almost all careers in this new technological society require a background in mathematics. However, as mathematics programs continue to teach to the industrial age, the number of students persisting in mathematics programs is dropping.

Mathematics educators are working towards major reforms. The goals of the 1992 Mathematics Framework for California Public Schools are: to produce "mathematically powerful students [who] think and communicate, drawing on mathematical ideas and using mathematical tools and techniques."

(p. 3) The five broad goals for students of mathematics defined in the 1989 Curriculum and Evaluation Standards for School Mathematics are:

(1) to learn to value mathematics
(2) to become confident in their ability to do mathematics
(3) to become mathematical problem solvers
(4) to learn to communicate mathematically
(5) to learn to reason mathematically (p. 5)

In order to meet these goals, teachers must make radical changes in how they teach mathematics. Teachers will need to take a constructivist approach toward mathematics education and teach mathematics based on how children
think. They will need to help students develop more complex, abstract and powerful mathematical structures so that students will be able to solve a wide variety of meaningful problems. Teachers will also need to help students become autonomous and self-motivated in their mathematical activity.

This project explores several ways in which these goals can be carried out in the primary classroom, including the integration of mathematics with other subjects, the use of educational activities which promote these goals, the use of literature to teach mathematics, and the use of thematic units.

Included in this project is a guide which updates teachers on what content and concepts need to be presented at each primary grade level, according to the California frameworks in mathematics, English-language arts, science and history-social science. This will be a quick reference tool for teachers planning units.

Sound educational activities which can be used to teach mathematics as well as other subjects are presented in this project. These are use of daily situations, games, and investigations.

This project also inservices teachers on how to use literature which effectively integrates subjects, especially mathematics. Included is an appendix of specific titles and information on what content and concepts can be taught through these books.
Finally, this project provides teachers with guidelines on how to plan thematic units, along with an organizer so that they can easily plan thematic units which integrate subjects. A sample unit is provided as well.
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SECTION 1: INTRODUCTION

As society moves from the industrial age into the informational age, the educational preparation of the student for future job and societal demands must radically change. The adults of the future will find themselves changing jobs often and find that specific skills learned in one job may not transfer to the other (National Council of Supervisors of Mathematics [NCSM], 1989). In order to succeed, they must be able to grasp new ideas, adapt to change, find patterns, and solve non-routine problems. In other words, Americans need to be able to think mathematically for a living (National Research Council [NRC], 1989).

The educational goals in a society in the present information age differ radically from those in an industrialized society. In the past, the goals of education in America were to teach all students the basic skills needed for a lifetime of work in an industrial and agricultural economy as well as to be informed voters, and to thoroughly educate a small group who would go to college and pursue professional careers (NCR, 1989).

As America has entered the age of information, these goals have changed. New goals for education include mathematically literate workers, lifelong learning, opportunity for all, and an informed electorate (National Council of Teachers of Mathematics [NCTM], 1989).
Almost all careers in the technological society of today require a background in mathematics (NCSM, 1989). Mathematics is the foundation of science and technology (NCR, 1989). The National Commission on Standards for School Mathematics, in its 1989 publication of *Curriculum and Evaluation Standards for School Mathematics* [denoted hereafter as *Standards*], states that to be prepared for the jobs of the future, students must:

- understand math concepts and principles
- reason clearly and communicate effectively
- recognize math applications in the world around them
- approach mathematics problems with confidence
- be able to apply mathematical concepts and skills to new situations (adapted from pp. 5-6)

Even though mathematics permeates all of society and the workplace, Americans have continued to permit underachievement in mathematical education. Seventy-five percent of American students stop studying mathematics before completing the prerequisites for functioning adequately on the job or in society. This achievement is well below what is needed to be a leading nation in a global technological world (NCR, 1989).

The American public has attributed this low achievement in mathematics to people's inborn inability to do mathematics. They have come to accept- and maybe even expect- their children's poor performance based on their own accomplishments in math (NCR, 1989).
The public needs to see that the mathematics of today involves more than the memorization of procedures and basic facts. Mathematics can no longer be taught with this as its primary goal. A new handling of mathematics is needed for the next generation to meet the economic, technical and defense needs of American society (Secada & Carey, 1990).

However, today's school continues to follow the structure in mathematics designed to educate the child for the industrial age. This current structure acts like a filter, sifting students out of programs leading to scientific and professional fields. American colleges lose half of the students in mathematics programs each year. This structure must be changed to fit the demands of the information age; an age where there is less manual and more mental, less mechanical and more electronic, less routine and more verbal, less static and more varied (NCR, 1989).

Recent research, as well as many publications by the National Research Council [NRC], the National Council of Teachers of Mathematics [NCTM] and others, has pointed the way towards reform in mathematics. This reform [which will be described in detail in the following section] has given impetus to the formulation of the 1992 Mathematics Framework for California Public Schools [hereafter denoted as Mathematics Framework]. In order for this reform to occur, teachers must make a radical change in how they teach
mathematics in school, from Kindergarten on up. This will include a change in
the school's curriculum and in the textbooks used in mathematics.

Current mathematics textbooks and most school district's curriculum do
not follow the state framework for mathematics, which emphasizes learning in
meaningful contexts. Problem solving, which is the main emphasis in the
Mathematics Framework, is still secondary to the learning of skills. Students
are expected to solve problems only after they master the needed skills. Word
problems, when presented, incorporate only the isolated skills currently being
addressed. Algorithms are taught to students too early- before students have
had a chance to understand the underlying concepts and create their own ways
to solve problems (Hiebert, 1990). Students do not learn in meaningful contexts
through this kind of curriculum.

Teachers are the number one deciding factor on what the mathematics
curriculum will be in their classes (Secada & Carey, 1990). Studies seem to
suggest that the majority of elementary teachers believe that the most important
part of mathematics to be taught is computations (Fey, 1979). Part of the
problem may lie in the fact that teachers have not received proper training on
the reforms in mathematics and are relying on their own education in
mathematics as a model for their curriculum choices. Teacher training is crucial
to the carrying out of the reforms in mathematics.
In the *Mathematics Framework*, as well as the 1987 *English-Language Arts Framework*, much emphasis is being placed on the integration of subjects and teaching for meaning as an important part of reforming education for the needs of our technological society. New reading and social studies textbooks adopted by the state of California try to facilitate the ease of integration of language arts, science and social studies. However, the integration of mathematics with other subjects which also follows the educational reform movement in mathematics has hardly appeared in mathematics textbooks or in a school curriculum (Secada & Carey, 1990). Many teachers may be unsure of how a meaning-centered mathematics program can be integrated into thematic units where problem solving is the main emphasis. Teachers need more training in this area as well.

This project will delve into how to teach mathematics for meaning and how to integrate mathematics with other subjects. It will address: How can mathematics be successfully taught in the primary whole-language classroom which can be integrated within thematic units and is aligned with the state frameworks in mathematics and language arts?
SECTION 2: REVIEW OF RELATED LITERATURE

Before mathematics can be integrated into thematic units, it must be clear that the mathematics being taught is aligned with the two major guidelines for mathematics: the 1989 *Curriculum and Evaluation Standards* developed by the National Commission on Standards for School Mathematics and the 1992 *Mathematics Framework For California Public Schools*. Also, the integration must be aligned with the 1987 *English-Language Arts Framework*. A brief synopsis of these guidelines is presented here as the foundation for comparison to current practices.

THE CURRICULUM AND EVALUATION STANDARDS FOR SCHOOL MATHEMATICS

The *Curriculum and Evaluation Standards for School Mathematics* [hereafter denoted as *Standards*], published in 1989, states the five broad goals for students of mathematics to be:

1. to learn to value mathematics
2. to become confident in their ability to do mathematics
3. to become mathematical problem solvers
4. to learn to communicate mathematically
5. to learn to reason mathematically (p. 5)

In order to achieve these goals, students need to be exposed to and examine various situations in which mathematics plays a role. There are four
facets of mathematics, which students of all grade levels need to experience: (1) Problem solving; (2) Interpersonal communication; (3) Reasoning; and (4) Interconnected mathematical knowledge.

The Standards also identifies eight specific content strands in mathematics: (1) numbers; (2) operations; (3) fractions and decimals; (4) measurement; (5) geometry and spacial sense; (6) probability and statistics; (7) algebra; and (8) patterns and relationships. It emphasizes that the content should be learned in meaningful contexts in which students can solve problems, make conjectures, reason, validate and prove their conjectures and communicate. Mathematics is seen as a social task, rather than knowledge to be passively absorbed.

At the elementary level, the Standards calls for increased emphasis on number sense, place value concepts, the meaning of decimals and fractions, and estimation of quantities; and decreased emphasis on early reading, writing, and ordering numbers symbolically. It stresses the meaning of operations, thinking strategies for basic facts, and the use of calculators over complex paper-and-pencil computations. In problem solving, it calls for word problems with a variety of structures, use of everyday problems, applications, the study of patterns and relationships, and problem-solving strategies; with a decrease in use of clue words to determine which operations to use. The Standards also
emphasizes number theory, discrete mathematics, probability and statistics, geometry, and measurement as critical for dealing with the technological changes in the twenty-first century.

Many educators view the Standards as merely calling for changes in content. However, its actual intent is to call for fundamental changes in instructional practices (Kamii & Lewis, 1990). This holds true in the area of assessment as well. The Standards proposes that the curriculum should dictate the assessment, not the opposite. Current standardized tests stress lower-order mathematics skills. They continue to motivate teachers to keep teaching computational skills (National Council of Supervisors of Mathematics, [NCSM], 1989). The reform of standardized tests is an important fundamental change that is called for in the Standards. These improvements will make mathematics more genuine and useful for all students.

MATHEMATICS FRAMEWORK FOR CALIFORNIA PUBLIC SCHOOLS

The 1992 Mathematics Framework for California Public Schools [Mathematics Framework] agrees with the need for fundamental changes in instructional practices. Basing much of its recommendations on the foundation of the Standards, the Mathematics Framework perceives the overall goal of schooling to be: "to equip students with the reasoning tools they need as good
7. Assessment is integrated with instruction; it focuses on what students understand and can do rather than on what they don't know or can't do.
8. The program is appropriate to the maturity and development of the students as it meets its other goals.
9. The program develops every student's positive disposition toward mathematics in several ways.
10. The program usually introduces computational procedures only when students need them. (p. 40-43)

The Mathematics Framework identifies eight strands of mathematical content and several unifying ideas which mesh together to help to design and implement a mathematical program. The eight strands are: number, measurement, geometry, functions, statistics and probability, logic and language, algebra, and discrete mathematics (p. 5). Unifying ideas are deep mathematical ideas which may include several strands and are important goals at varying grade levels (p. 6). Unifying ideas help to integrate subjects as well as add a different dimension to the content of mathematics.

The strands and unifying ideas are incorporated into the curriculum within the context of units. Units are large chunks of subject matter which may use more than one strand and/or unifying idea. They typically last from one to six weeks, depending on the age of the students and the nature of the unit. They feature larger projects (termed investigations) which are meaningful to the students. Instruction and assignments provide the needed tools in order to
complete the investigations. All activities relate to the larger context of the unit (p. 7).

An average of ten units is presented each year. Most are to be integrated within a thematic unit and deal with real-life experiences. A few units may deal with discrete mathematics within a meaningful context. Smaller fragments of time may be spent outside of or between units for ideas that do not fit into units (p. 98).

Assessment for these more open-ended investigations will be done through alternate standards such as rubrics (matrices). Students will be given opportunities to refine their work if it does not meet the criteria of the investigation. Thus, students will be given the opportunity to succeed in mathematics in a way that is purposeful and meaningful.

THE ENGLISH-LANGUAGE ARTS FRAMEWORK

The 1987 English-Language Arts Framework states its main goals as follows:

- To prepare all students to function as informed and effective citizens in our democratic society
- To prepare all students to function effectively in the world of work
- To prepare all students to realize personal fulfillment (p. 1-2)

These goals are fundamentally parallel to those of the Mathematics Framework. Both emphasize societal goals as well as personal goals pertaining to their
respective subject. This makes it possible to integrate these subjects without
impinging upon each other's goals.

The framework for language arts, describing research on how students
learn and use language, states that human beings use language in these ways:

1. **Constructively**, when they create new meaning by integrating new
knowledge with old.
2. **Actively**, when they become involved with learning enough to
relate it to their own goals and purposes.
3. **Interactively**, when they communicate what they learn to others.
4. **Strategically**, when they plan language to suit their purposes and
perform a task effectively.
5. **Fluently**, when they approach each new reading and writing task

In order for learning to occur, students must want to communicate and must be
skilled in reading, writing, speaking and listening. This will open up the
avenues for learning.

Reading, writing, speaking and listening are different facets of language
arts, but are not to be taught in insolation (p. 6). They should be integrated
together with the supporting skills of grammar, spelling and handwriting. The
framework calls for a sense of wholeness within a literature-based program.
Students are to see the connections between the tasks they attempt and their own lives (p. 7).

The understanding of meaning is cited as the most important reason for learning a language in the primary grades. It should be the focus of all of the activities. Language arts programs in the primary grades should be integrated, purposeful and constructive (p. 28). Writing plays an important role in the learning of reading. Primary writing programs should introduce the stages in writing: prewriting, drafting, revising and editing (p. 28).

Students need to be assessed in an authentic manner, which includes daily informal assessments as well as more formal evaluations. These assessments take the place of objective tests which do not give a clear enough assessment of student progress, as they do not take into consideration the complexity of language development (p. 35).

The English-Language Arts Framework parallels the Mathematics Framework and the Standards on the concept of creating environments in which students can succeed. Furthermore, students will only be motivated to succeed when the work is meaningful to them.

THE PLAGUE OF THE TRADITIONAL CLASSROOM

Unfortunately, the traditional classroom has been unsuccessful in creating powerful doers of mathematics. Industries and universities spend a
great deal of time and money on remedial mathematics courses each year (National Research Council [NCR], 1989). In her review of research spanning from 1928 to 1981, Fischer (1989) stated that the findings cited the most common explanation for poor achievement in mathematics as being the instructions the students received. This indicates that mathematics is not being taught correctly the first time.

Traditionally, mathematics is taught through a spiralling curriculum in elementary schools (Porter, 1989 in Secada & Carey, 1990). The same curriculum is covered for three or more years, but in more depth each succeeding year. What starts off as new the first year becomes review by the third. This spiralling curriculum tends to stress the same low level content each year.

The goals of current mathematics textbook series are very different from the goals of the National Council of Teachers of Mathematics [NCTM]. The objectives of textbooks stress teaching techniques to children that will help them to write correct answers in the correct conventional forms. Only one specific technique is presented at a time, with many exercises of the same type to promote mastery of the techniques (Kamii, 1989).

Porter (1989) and Porter, Floden, Freeman, Schmidt and Schwille (1988) have documented that elementary teachers spend a considerable amount
of time reviewing the last year's math. Then they have to rush through chapters or even skip some so that they can get through the text before the end of the year. Students end up spending more time on the same computational work and less time on new and important learning (Secada & Carey, 1990). Challenging mathematics concepts rarely get taught because they usually appear at the end of the textbooks and teachers have run out of time to go into depth with them (Secada & Carey, 1990).

The curriculum that does get covered each year in elementary classrooms has an overwhelming emphasis on basic skills (Fey, 1979). Children are merely exposed to mathematics and then expected to drill and memorize (Brown, 1991). It is typically found that students view school mathematics as being arbitrary rules and conventions (Cobb et al., 1991). Students forget facts because they see no practicality in the mathematics they're learning (Secada & Carey, 1990).

Carpenter (1985 in Secada & Carey, 1990) has found that when students first come to school, they bring with them a rich background in mathematics. When they get to school, the mathematics curriculum ignores this. Students then begin to separate school mathematics from real-life mathematics. They consider school mathematics to be just unrelated facts and algorithms which
need to be memorized for tests, but can be forgotten afterwards with no real consequences.

This "industrial age" curriculum is based on the "back-to-basics" movement. Basic skills were the main emphasis of this movement (Doll, 1993). This is too narrow an approach to mathematics. Basic skills are not enough to help people to function effectively in the twenty-first century (NCSM, 1989).

In order to function in the new century, students will need to become problem-solvers (NCSM, 1989). Current textbooks place more of an emphasis on computational proficiency than on understanding basic concepts. This has caused students to have difficulties in solving non-routine problems (Carpenter, Corbitt, Kepner, Lindquist, & Reys, 1980).

Traditionally, schools focus on separate skills in mathematics. Students are expected to integrate these skills and apply them to word problems without teacher instruction (Brown, 1991). The emphasis in problem-solving has been on key words and specific ways to analyze a problem, which is an ineffective way to teach problem-solving (Carpenter et al., 1980; Suydam & Weaver, 1977). Word problems should be modeled after the way that children naturally solve problems (Carpenter & Moser, 1984).

Brown (1991) argues that traditional mathematics is based on three major instructional myths. The first is that thinking is made up of separate cognitive
skills in sequential steps. This implies that all thinking is linear in nature. It also suggests that these separate pieces can be successfully put back together to lead to the understanding of content. However, it is understanding that is directly linked to the application of mathematics; not the memorization of facts.

Brown's second myth is the "right answer myth." It focuses on getting the right answer rather than on understanding. This is essentially drill and practice. Conversely, students need to organize knowledge before they can remember it. They need to be able to figure out how it all fits together and assimilate the new knowledge with the old. This helps the student in the process of problem solving.

Brown's third myth is that chronological age is the determinant for whether or not a child can learn a concept. Research suggests that by providing instruction that is matched to what a child knows already, the child can learn things previously thought to be "above their grade level."

The traditional "back-to-basics" mathematics curriculum is based on incorrect and outdated assumptions about how people construct knowledge (Kamii, 1985). Traditionally, knowledge is considered to be an entity which can be identified and has a value of absolute truth (The Cognition and Technology Group at Vanderbilt [CTGV], 1991). The goal of instruction, then, is that students acquire this knowledge. Most authors of mathematics textbook
series hold the empiricist view that learning can be divided into four basic levels:

1) The concrete level- the counting of real objects
2) The semi-concrete level- the counting of objects in pictures
3) The symbolic level- the use of written numbers
4) The abstract level- the generalizing of number relationships
   (Kamii, 1989)

Instruction needs only to be sequenced and delivered in as "teacher-proof" a way as possible (CTGV, 1991).

This has led teachers to also place the emphasis of mathematical education on computational skills. In the past, teachers have been reluctant to spend more time on problem solving or understanding because they thought it would take too much time away from the teaching of computational skills (National Advisory Committee, 1975; Romberg & Carpenter, 1986 in Carpenter, Fennema, Peterson, Chiang, & Loef, 1989).

Also, a majority teachers feel that students need to learn number facts before they can solve problems (Peterson, Fennema, Carpenter, & Loef, 1989 in Carpenter et al., 1989). This "building block" approach to teaching mathematics is based on the assumption that students must have a foundation of lower-order thinking skills before they can support higher-order
problem-solving and application skills (Peterson, Fennema, & Carpenter, 1988-89).

Research has shown that teachers have not been using knowledge of their students' thinking to make instructional decisions (Carpenter et al., 1989). Assessment of students' knowledge is not a primary concern of most teachers. Most teachers follow a specific curriculum with only minor adjustments based on feedback from students. Teachers need to be updated on how students think, so they can make intelligent instructional decisions.

CONSTRUCTIVISM: AN ALTERNATIVE TO THE TRADITIONAL VIEW

The National Research Council, in its publication Everyone Counts: A Report to the Nation on the Future of Mathematics Education (1989) states that the main objective of mathematics education in the elementary school should be to develop number sense. Constructivism is a philosophy of teaching which may be able to carry out this goal.

The theoretical perspective of constructivism avers that students actively and personally construct their own knowledge as opposed to memorizing knowledge in textbooks or given by teachers (Silver, 1990). Constructivism has its foundation in the theories of Jean Piaget, based on his extensive research spanning from the 1920's to the 1980's.
In his studies, Piaget observed that the actions of the child appeared to be his/her fundamental source of knowledge; rather than the traditional view that perception and language are the source of knowledge. From these studies came his psychological theory- which later became widely accepted- that the child is active in the creation of knowledge for him/herself. This is performed through constructive processes which are innate in the child (Beilin, 1992).

The basic tenets of constructivism- which are embraced to a greater or lesser extent by different proponents- are:

1. Knowledge is actively created or invented by the child, not passively received by the child (Bruner, 1986 in Kamii & Lewis, 1990).
2. Children create new mathematical knowledge by reflecting on their physical and mental actions. Ideas are constructed or made meaningful when children integrate them into their existing structures of knowledge (Bruner, 1986 in Kamii & Lewis, 1990).
3. No one true reality exists, only individual interpretations of the world. The interpretations are shaped by experience and social interactions (This tenet is perhaps the most controversial.) (Bruner, 1986 in Kamii & Lewis, 1990).
4. Learning is a social process in which children grow into the intellectual life of those around them (Bruner, 1986 in Kamii & Lewis, 1990).
5. When a teacher demands that students use set mathematical methods, the sense-making activity of students is seriously curtailed (Kamii & Lewis, 1990, p. 34-35).

The constructivist perspective implies two major goals for mathematics instruction. The first goal is that students develop more complex, abstract and
powerful mathematical structures so that they will be able to solve a wide
diversity of meaningful problems. The second goal is that students become
autonomous and self-motivated in their mathematical activity (Kamii & Lewis,
1990).

HOW STUDENTS CONSTRUCT KNOWLEDGE

In order to help their students reach these goals, teachers need to know
how students construct knowledge (Kamii, 1985). Recent research in the area
of cognitive psychology suggests that the student's mind is more like tinker toys
than a tower of blocks (Peterson, Fennema, & Carpenter, 1989-90).

Knowledge is stored as a network of concepts, or constructs. Learning is
viewed as the process of making connections between new information and the
stored network of knowledge (Peterson, et al., 1989-90). It is an active, social,
problem-solving process (Cobb et al., 1991).

Piaget explains children's construction of knowledge in these key ideas:

1) The mental structures of children are different from those of
   adults. They have their own way of viewing and interpreting the
   world around them.
2) Children develop mentally through definite stages. These stages
   are the same for all children and are in a fixed order.
3) Children move through these stages at different ages and at
different rates. A child can be in one stage for some things and
   another stage for others.
4) Mental development is influenced by four interrelated factors:
   physical maturation, experience, social interaction- especially
   with other children, and equilibrium. The child does this by
assimilating new concepts into his/her existing mental schemes or accommodating his/her schemes to the new concepts.

5) Children go through three stages of mental development: intuitive thought from ages four to seven, concrete operations from ages seven to eleven, and formal operations from ages eleven to fifteen.

6) "Operations" are carried out mentally and are elements of rational thought. They are: conservation- number, length, and quantity stay the same even when the position, shape or grouping changes; and reversibility- any change in position, shape or grouping can be reversed to its original position, shape or order.

7) Children's stage of mental development limits what they can learn and how they learn.

8) Thought grows from actions, not from words.

9) One cannot give knowledge to children. It is discovered and constructed through their activities.

10) Children learn best from concrete experiences.

11) Children are actively trying to make sense of their world. They continually recreate their mental structures, making it possible to dealing with more complex information.

12) Children are not truly learning unless their mental structures are complex enough to handle the information. Otherwise, the learning will be superficial, not useable, and will not last (Charles, 1974).

Piaget made a distinction between three kinds of knowledge: physical, logico-mathematical and social. Physical knowledge is knowledge of physical properties that are in objects, such as color and weight. This is empirical knowledge and has its source partly in objects. Logico-mathematical knowledge consists of relationships which are created by individuals, such as differences in colors and weight. The source of this knowledge is inside each individual's mind. Social knowledge is knowledge agreed upon by people, such as the color
blue is called "blue" and Christmas is celebrated December 25th. The source of social knowledge is in the conventions people agree upon (Kamii, 1990).

The concept of number is logico-mathematical knowledge. It is created mentally by each individual. While three objects are physically observable, "threeness" cannot be observed. If numbers were learned by empirical abstraction from sets that are already made, a child would have to see a set of one million objects in order to understand one million. However children are able to understand this by relating it back to relationships in their minds (Kamii, 1985).

According to Piaget (Kamii, 1985), the concept of number is a synthesis of two kinds of relationships which the child creates among objects by reflective abstraction: order and hierarchical inclusion. Order refers to the mental ordering of objects so that all are included and none are counted more than once. Hierarchical inclusion refers to the ability to recognize that all the objects in a given set make up the number, not just the last object. Eight means all eight objects; not just the last object the child points to when counting to eight (Kamii, 1985).

Piaget delineates between three developmental levels that a child goes through to construct the concept of number in his/her mind. At level I, the child cannot make a set that has the same number as the set presented. At level
II, the child can do this, as he/she begins to construct the logico-mathematical structure of number. However, the structure is not strong enough to conserve the equality of the two sets if the objects in one set are spread apart farther than the other. At level III, the child can now view the sets numerically, rather than spatially. This does not occur until the child is seven to eight years of age, when his/her thought becomes reversible (Kamii, 1985).

Kamii explains the implications of Piaget's work regarding the concept of number on teaching mathematics in the primary grades:

1) Number is not empirical knowledge. The child constructs it by reflectively abstracting from his/her own mental action of putting things into relationships (1990, p. 26).

2) Number concepts cannot be taught. Number does not have to be taught, because the child constructs it naturally it from within (1990, p. 26).

3) Addition also does not need to be taught. The very construction of number involves the repeated addition of "1" (1985, p. 25).

4) Goals and objectives need to be focused on children's thinking rather than on their writing correct answers (1990, p. 27).

5) Children need to be encouraged to agree or disagree among themselves rather than being reinforced for right answers and corrected for wrong ones (1990, p. 27).

TEACHING MATHEMATICS BASED ON HOW CHILDREN THINK

The teacher is the most important factor in shaping the character and effectiveness of mathematics education (Fey, 1979). It is mainly the teacher who decides what the mathematics curriculum will be for the year (Secada &
Carpenter, Fennema, Peterson, Chiang and Loef (1989) found that a significant positive correlation exists between student achievement in problem-solving skills in addition and subtraction and the teacher's belief on instruction. First-grade students- who had teachers who believed that instruction should build on children's existing knowledge and helped them construct knowledge rather than absorb it- did better on tests on strategies used as well as standardized tests than did students in the control groups.

Research by Cobb and others (1991) found that students receiving constructivist teaching performed as well as those taught by traditional teachers on standard computations. However, they solved problems differently and developed a higher level of reasoning. Students succeeded more in understanding when teachers valued individual and collaborative attempts to understand and figure out how to make sense. When teachers change from teaching traditionally to letting students interpret, students can change to become more meaning-centered (Cobb, Yackel, & Wood, 1989 in Nicholls, Cobb, Wood, Yackel, & Patashnick, 1990).

Studies have found that the teaching method employed by teachers will also effect the student's beliefs about mathematics. Students in traditional classrooms tend to think that success in mathematics is based more on ability than effort (Nicholls, Cobb, Wood, Yackel, & Patashnick, 1990). Students in
constructivist classrooms tend to attribute success in mathematics to understanding and collaborating. Success is not necessarily based upon conforming to the teacher's rules and procedures (Cobb et al., 1991). Even second graders can tell whether a teacher is emphasizing that effort alone leads to success in mathematics or that effort to understand leads to success (Nicholls et al., 1990).

It is the role of the teacher to introduce and guide the process of constructing mathematical meanings rather than to just cue students to figure out the procedure the teacher had in mind. In order to accomplish this, the teacher needs to: highlight the conflicts between the interpretations and solutions of students, help students to collaborate, facilitate students as they discuss mathematics together, pick out parts of the students' interpretations or solutions for further discussion, describe a student's explanation, and assume that the student's point of view is reasonable, even if it not immediately clear to the teacher (Cobb, et al., 1991).

According to Carpenter, a constructivist teacher needs to follow these guidelines to be successful:

1) Problem-solving is the organizing focus of all instruction.
2) Instruction should be organized so that students can actively form their own knowledge and understanding.
3) Students should relate the problem, concept or skills to the previous knowledge he/she already has.
4) The emphasis should be on learning how the learner solves problems and using that information to guide further instruction (Carpenter et al., 1989).

INTEGRATING MATHEMATICS ACROSS THE CURRICULUM

The Mathematics Framework, in recognizing that mathematics plays a role in other disciplines and permeates all facets of society, considers the integration of mathematics to be an important goal over the next ten years, and that it may provide the solution for the inability of the current mathematics curriculum to make mathematics meaningful to students. Integration helps the student to feel a sense of purpose. This helps the student to make connection between school and real life (Ryan, 1986 in Jamar & Morrow, 1990). This also helps the student to connect topics within mathematics and across the curriculum so that students view education holistically, rather that topics in isolation (Hatfield & Price, 1992).

Most sources addressing this goal dealt solely with the integration of reading, writing and mathematics. Types of writing activities in mathematics were summarized, such as: daily summaries, the formation of word problems, explanations of procedures and concepts, and reflections on the day's work (Brown, 1991). It is crucial that reading, writing and mathematics be relevant and of interest to the student in order for the student to retain knowledge and apply it to other situations (Jamar & Morrow, 1990).
The integration of mathematics across the curriculum needs to be more than merely an integration of reading, writing and mathematics. All subjects should be integrated in the form of thematic units. Thematic units help form long-term and extended connections between mathematics, other subjects, and daily life (Crawley, Baker-Kroczynski, & Urban, 1992). However, very few references are available which describe the successful integration of mathematics into thematic units for the primary classroom. Thus there is an evident need for this project.

Furthermore, the *Mathematics Framework* warns that haphazard integration of mathematics with other subjects can result in a watering down of the curriculum. Therefore, it gives several guidelines to consider when designing an integrated unit:

1) The assignment, unit, or course should advance learning in each of the subjects integrated.
2) The assignment, unit, or course should focus on curricular goals that are central to all of the subjects integrated.
3) An integrated assignment should be assessed from more than one perspective (p. 102).

These guidelines, as well as the guidelines for teaching students from a constructivist perspective, will be the foundation for this project’s integration of mathematics in thematic units for the primary classroom.
SECTION 3: STATEMENT OF GOALS AND OBJECTIVES

The first goal of this project was to produce a guide which encourages teachers to integrate subjects into thematic units. This guide also updates teachers on what content and concepts need to be presented at each grade level according to the California frameworks, in mathematics, English-language arts, science and history-social science. This is to be used by primary teachers to facilitate the integration of these subjects into thematic units.

A second goal of this project was to inservice teachers on how mathematics in the primary grades should be taught so that it follows the child's cognitive structures and abilities. The project emphasizes three major vehicles for teaching mathematics as well as the other subjects: daily situations, games, and investigations.

A third goal of this project was to inservice teachers on how to use literature which effectively integrates subjects, especially mathematics. It also provides teachers with specific titles and information on what content and concepts can be effectively taught through these books.

Finally, this project was to provide teachers with guidelines on how to plan thematic units, along with an organizer so that they can easily plan thematic units which integrate subjects. A sample unit is provided.
SECTION 4: DESIGN OF THE PROPOSED PROJECT

This project is in the form of a handbook for primary teachers. The handbook is divided into four parts, based on the four goals delineated in the last section. Each part is presented as an integral tool that primary teachers will need in order to successfully integrate mathematics into thematic units. A final section includes a design of a field test of the project, including an evaluation form for teachers to judge the usefulness of the project.

INTEGRATION

The first part of the project discusses the rationale behind the integration of subjects into thematic units. It also updates teachers on the goals and objectives of the California frameworks in mathematics, English-language arts, science and History-social science, as well as what content and concepts need to be presented at each grade level. All four frameworks are reviewed and presented in narrative form. This allows teachers to compare the four frameworks to better plan thematic units at each grade level.

LEARNING ACTIVITIES

The second part of the project presents four vehicles for teaching mathematics and other subjects in the primary grades, which follow the child’s cognitive structures and abilities: daily situations, games, and investigations.
The background and rationale for each type of activity is presented. Examples which can be used by the classroom teacher are given for each.

MATHEMATICS AND LITERATURE

The third goal is met by a section of the handbook on mathematics and literature. It provides background inservice on the subject. Appendix I contains a list of literature which effectively integrates subjects, especially mathematics, and which teachers can use with their thematic units. It provides information on what content and concepts can be effectively taught through these books. Appendix II provides references for more information on using literature to teach mathematics.

THEMATIC UNITS

The fourth part of the handbook is designed to equip primary teachers to begin teaching in thematic units. Steps in organizing a thematic unit are described in detail. Appendix III contains sample outcomes to guide teachers in designing units. Appendix IV provides an organizer so that teachers can easily plan thematic units. The organizer is to be used in conjunction with the information on course content and concepts provided in the first part, exit outcomes developed by proponents of outcome-based education, and learning activities described in the project. A sample of a thematic unit is given in Appendix V.
FIELD TEST

The project will be field tested in three ways. First, the project will be read and evaluated by several primary teachers in Southern California.

The project will also be implemented at a school in Southern California with a group of primary teachers. At the end of the year, they will evaluate the use of the information and organizer and give suggestions for improvements.

A third field test of the project will be through working intensively with one teacher for a year. At the end of the year, this teacher will evaluate the success in teaching mathematics through these methods.
INTEGRATION

The integration of disciplines into thematic units provides the student with a holistic view of education, wherein relationships between the subjects will be perceived and reinforced (National Research Council [NRC], 1990 in Dolan, February 1991). It is recommended by the Curriculum and Evaluation Standards for School Mathematics [Standards], as well as by the California Frameworks for mathematics, English-Language Arts, Science, and History-Social Science.

The Standards states that "in K-4, math should include opportunities to make connections so that students can use math in other curricular areas" (1989, p. 32). It also stresses that "children... need to understand that mathematics is an integral part of real-world situations and activities in other curricular areas" (1989, p. 18). The Mathematics Framework for California Public Schools [Mathematics Framework] concurs. "As mathematics pervades all facets of society, its integration with other school subjects becomes an important goal. Over the next ten years, curriculum designers at all levels, including teachers, can make important progress toward achieving that goal" (1992, p. 101). The 1987 Mathematics Model Curriculum Guide adds "In integrated units of study, teachers emphasize the rich connections among content areas, teach students the
interrelatedness of knowledge and skills, and foster a holistic view of learning" (p. vi).

The other main Frameworks agree. The 1987 *English-Language Arts Framework* supports writing across the disciplines, as it helps students to integrate what they are learning to what they already know and makes it meaningful to them. The 1988 *History-Social Science Framework* was designed to "bridge the barriers between the related disciplines and to enable students to see the relationships and connections that exist in real life" (p. 28). The 1990 *Science Framework* adds "Scientific literacy could receive a considerable boost if science were used as a vehicle to enhance reading, mathematics, and the arts. The use of science to teach other fields has been shown to be quite successful in many exemplary science programs. Science reading should be encouraged and integrated in the overall curriculum" (p. 161).

The successful integration of subjects into thematic units by California teachers must include the key learnings mapped out in the four main Frameworks for California. Presented here is a synopsis of the key learnings found in each Framework. The format varies for each Framework, based upon the format used by that Framework. Following this is a list of suggested topics that can be vehicles to integrate these subjects.
ENGLISH-LANGUAGE ARTS

The Kindergarten language arts program focuses on the understanding of meaning. It must provide flexibility in pacing and content, due to different levels of readiness in the students.

Students should hear good literature being read aloud daily. This will help them to develop an ear for written language, increase their vocabulary, develop a common background of content, and build a love of reading. Teachers should model active listening.

Students should have many opportunities to express themselves, including puppet theaters, "show and tell" times, and the sharing of experiences or pictures.

Students in grade one are experiencing "emerging literacy." The emphasis for all language arts activities continues to be the understanding of meaning. As in the Kindergarten program, students should have many opportunities to express themselves orally. Speaking and listening skills are an integral part of language arts.

Students need to read and hear good literature. Common words from the environment and from student-written stories, as well as phonics instruction, are important in helping students understand the relationships between letters and sounds so that they can understand meaning.
Early writing programs introduce instruction in prewriting, drafting, revising and editing. Writing conventions are taught as subskills as needed to meet the individual student's needs and as aids to the written communication process.

Students in grade two begin to experience "extending literacy." They are starting to be more fluent in language and are more ready to use it to explore learning in many different ways.

Students continue to read, hear, and respond to good literature. The second grade program continues to strengthen reading, writing, speaking and listening skills within the context of understanding meaning.

HISTORY-SOCIAL SCIENCE

The Kindergarten program is entitled "Learning and Working Now and Long Ago." Students learn to share the teacher's attention with others and learn to consider the rights of others in the use and care of classroom materials. Children analyze classroom problems and stories, fairy tales, and nursery rhymes which incorporate conflict and value issues.

Children build self-worth through their understanding of their world and discovering their ability to explore, create, solve problems, communicate, and assume individual and group responsibilities. Students explore the school and its neighborhood, and use materials to act out neighborhood structures.
Students will begin to develop a sense of historical empathy. They observe the ways people lived in earlier days and compare themselves to children from the past.

The grade one program is entitled "A Child's Place in Time and Space." Students develop the values of fair play and good sportsmanship, respect for the rights and opinions of others, and respect for rules by which we all must live. Students analyze the social problems and decision-making dilemmas that occur in the classroom, as well as stories and fairy tales. Students can help develop civic values through discussions and role-playing activities.

Children develop the relationships between local places and other places which supply their needs. They observe and analyze changes in their neighborhood. Children build three-dimensional models of their neighborhood and compare to maps. Through literature and other studies, students begin to understand that the place where they live connects with the wider world.

Students discover the many ways in which people, families, and cultural groups are alike as well as those ways in which they differ. Through stories of today, as well as fairy tales, folk tales and legends, students discuss and analyze cultures, beliefs, customs, ceremonies, traditions and social practices.

The grade two program is entitled "People Who Make a Difference." Students develop an appreciation of the many people who work to supply their
daily needs (particularly food). Students visit markets and make models of the neighborhood highways and businesses. They make connections through picture maps and flowcharts of how we get our goods and services. Through geographic learning, students learn map skills.

Children learn how parents, grandparents, and ancestors made a difference and develop a beginning sense of history. Students construct a family history. They learn how their ancestors came to America, which ties in the globe, transportation, and culture.

Students will be introduced to the lives of people from many cultures who have made a difference. They should conclude that people matter.

SCIENCE

The K-3 science program stresses the skills of observing, communicating, comparing, ordering and categorizing. Key learnings for the K-3 program are listed by science discipline and are not divided into separate grade categories.

Physical Sciences

A. Matter- Matter has weight and occupies space. It exists in three forms. It has many properties. Tiny cells can be seen through a microscope. Solutions are formed when added to water.
B. Reactions and Interactions- Two substances interact to form new substances. Change can be affected by surroundings or initiated by providing energy.

C. Force and Motion- The motion and speed of an object can be described. Force is the name for pushes and pulls. Several forces may affect an object. Machines can be simple or more complicated. The purpose of machines is to change the effect of an applied force.

D. Energy- Sources and Transformations- Energy is used to work or to change the form of matter. Energy is used to do mechanical work. We have renewable and non-renewable resources.

E. Energy- Heat- Heat energy comes from the sun, other light sources and fire. Heat flows to a cooler region. It keeps us warm. We use it to drive heat engines to do mechanical work.

F. Energy- Electricity and Magnetism- Electricity can be static or made to flow and run machines. Electricity can be dangerous. It runs machines and appliances. Magnets separate materials. They are used to hold notes, etc.

G. Energy- Light. Light comes from objects and enter our eyes. A picture of what we are looking at is made in our eyes and our brain. We can classify light by brightness and color. Light can be reflected in mirrors and other devices.
H. Energy- Sound- Sound comes from vibrations and can travel through objects. The ear receives sound. Loud sounds can cause damage to the ears. We use sounds to communicate with one another.

Earth Sciences

A. Astronomy- Includes days, seasons, phases of the moon, stars, rotation and revolution of the earth and eclipses. The universe is big and varied. Most things are too far away to visit them.

B. Geology and Natural Resources- The earth's surface has changed over time. Stress on the earth's crust is released through earthquakes and volcanoes. Rock are made of minerals and were formed in different ways. The earth is constantly changing. We need to conserve, reuse and recycle our resources.

C. Oceanography- The ocean is part of the water cycle. Oceans are vast bodies of salt water. Water in the ocean is always moving and affects our weather. We use oceans in various ways.

D. Meteorology- The earth is surrounded by the atmosphere. It is warmed by the sun. The water cycle plays a prominent role in weather. The earth has hot and cold places. Weather changes all the time. Weather forecasting is difficult. Severe weather can cause damage.
Life Sciences

A. Living Things- can be distinguished from non-living, can be classified, and have specific needs to grow. They have structures that do specific things to help them meet their needs. All living things are related; some are extinct. Humans use plants and animals.

B. Cells, Genetics and Evolution- All living things are made of smaller structures. Living things resemble their parents. Fossils tell use about the past.

C. Ecosystems- Living things need resources from the environment to help them grow. Some produce their own food; others get them from plants and animals. Living things depend on each other. Energy is gained from the environment. Animals and plants go through life cycles. Ecosystems change over time. Humans affect the environment.

The information provided above may seem very overwhelming. In order to help the reader to conceptualize this by grade level, presented here is the description for the Scholastic Science Place series, which was approved by California for adoption in 1993:

Yellow Level (Kindergarten)- Scale and Structure

Alive- Life is diverse.

Your Senses- Humans use their senses to gather information about the world around them.
Day and Night- Changes on the earth can be observed.

Your Earth- The environment contains diverse interrelated resources.

Matter- Matter and energy have observable characteristics.

What We Use- People use a variety of materials.

Red Level (First grade)- Systems and Interactions

Living Things- A living thing has structures that work together to help it survive in the environment.

Body Systems- The human body has parts and systems that work together.

Air, Sun, and Water- The sun, air, and water make weather, which can be observed and measured.

Using Trash- Through conservation methods, people can control the amount of waste they produce.

Solids, Liquids, and Gases- Matter changes in a variety of ways.

How People Move Things- People have invented ways to move living and non-living things from place to place.

Blue Level (Second grade)- Patterns of Change

Life Cycles- Living things change.

Staying Well- In order to function and grow properly, the human body has certain needs that must be met.
Rocks and Soil- Earth is changing.

Using Water- Water is a natural resource that people use and change in various ways.

Energy- Energy exists in different forms.

How People Get Food- People have invented ways to produce, process, and distribute food.

(This information was taken from a flyer distributed by Scholastic about the program.)

MATHEMATICS

The Kindergarten Program

Attributes and Classification- Students learn through early sorting experiences.

Understanding Number and Numeration- Students count and arrange objects to represent an amount concretely. They compare groups of objects.

Understanding Arithmetic Operations- Students use ideas of operations to solve questions in everyday situations as an extension of counting.

Dealing with Data- develops out of curiosity about classmates and everyday events. Students count and measure, order and compare.

The Process of Measurement- is exploratory. Students directly compare two objects, use non-standard units to measure length.
Measuring geometric Figures- same as above.

Locating and Mapping- Students develop locational vocabulary naturally. Students take walks and informally compare distances.

Visualizing and Representing Shapes- Students informally play with blocks, construct figures.

Exchange- Students buy things with money, trade items, play store, trade coin amounts and discuss whether exchanges are fair.

Games and Rules- Students learn rules and play games. They take turns. They discuss the fairness of situations.

**Grade One**

Attributes and Classification- Students make collections of things that go together, play guessing games to sort collections, or identify a specific object in a collection.

Understanding Number and Numeration- Students show that there are various ways to arrange a number of objects. They count by ones, upward and backward, and skip count. They cut fruit (or other objects) into halves or fourths to share.

Understanding Arithmetic Operations- Students solve everyday situations experientially. They use number sentences to record their experiences. From their many experiences, they recall some addition/subtraction facts.
Dealing with Data- Students count and measure, order and compare. They record their findings with pictures and simple graphs.

The Process of Measurement- is exploratory. Students directly compare objects, use non-standard units to measure length.

Measuring Geometric Figures- same as above.

Locating and Mapping- They tour the school and the neighborhood and share various routes to the same location. They share distances by number of steps.

Visualizing and Representing Shapes- Students make two- and three-dimensional shapes and figures. They make tracings or drawings to record what they have done. They look for shapes in the real world.

Exchange- Students buy things with money, trade items, play store, trade coin amounts, and discuss whether exchanges are fair.

Games and Rules- Students learn rules and play games. They take turns. They discuss the fairness of situations.

**Grade Two**

Attributes and Classification- Students begin to classify things by two overlapping attributes. They use clues for solving riddles and develop ways to record and communicate their classification system.
Understanding Number and Numeration- Students count, compare, order and estimate larger quantities. They begin to investigate place value. They use fractions and decimals encountered in everyday situations. They find halves (and other common fractions) of wholes and groups.

Understanding Arithmetic Operations- Students continue to solve everyday problems by acting them out, drawing pictures or diagrams, and using materials. They explore different ways in which they can use an operation. They learn their facts through their many encounters with numbers.

Dealing with Data- Students do simple surveys, choose categories and explore different ways of displaying the data.

The Process of Measurement- Students measure using non-standard units. They discuss the need for standard measures. They practice "reading" measuring instruments.

Measuring Geometric Figures- Students measure the linear dimensions of different objects. They explore the concept of area, perimeter and volume using non-standard measures. They compare sizes.

Locating and Mapping- Students write directions to get from one place to another. Students make maps and models of the classroom, school and home.
Visualizing and Representing Shapes- Students become aware of the properties of shapes. They build shapes from other shapes.

Exchange- Students "buy" items, calculate the total cost, "pay" for them, and make change. Students compare the price of items.

Games and Rules- Students play thinking games. They discuss strategies for playing a game. Students begin probability activities.

THEMES

The themes suggested here may be conducive to incorporating all or some of the different school subjects. These themes were chosen by compatibility to the Frameworks. This is certainly not an exhaustive list. Many themes appear in all grade level lists, but would be approached differently in each grade level. Some themes are very broad and could be divided into smaller thematic units.

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LEARNING ACTIVITIES

A variety of learning activities can be incorporated in planning thematic units which integrate mathematics with other subjects. This project presents the rationales and samples of three learning opportunities: daily situations, games, and investigations.

DAILY SITUATIONS

Within the classroom each day, situations arise which can be turned into powerful teaching moments. Daily situations give opportunities for students to structure and define problems from the real world. Real-world problems require non-routine problem-solving skills. Students can learn how to solve these problems by formulating their own problems and figuring out their own ways to solve them (Kamii, 1985).

The Standards supports the use of daily situations to construct number meanings and to interpret the multiple uses of numbers that are encountered in the real world. It states "most mathematical ideas in the K-4 curriculum arise from the everyday world, [and] they must be regularly applied to real-world situations. Children also need to understand that mathematics is an integral part of real-world situations and activities in other curricular areas" (NCTM, 1989, p. 18). It recommends that "teachers seize opportunities that arise from classroom situations to relate different areas and uses of mathematics" (NCTM,
The 1987 *Math Model Curriculum Guide* also stresses the use of a real-world setting for the practicing and reinforcement of concepts and skills. When students build the mathematical ideas of an operation from real-world problems, they begin to see the many kinds of situations associated with an operation. This will help them to recognize what operation applies to a problem situation and to better understand the operation in a more abstract way (Trafton & Zawojewski, November 1990).

The daily calendar is an excellent source of problem solving (Kamii, 1985, 1989, Edwards, 1990). Students learn about time within a meaningful context. Students can figure out how many days/weeks/months to a specific event. The significance of the date in history can be turned into problems to solve. The numerical value of the date itself can be discussed (odd, even, prime, etc.).

"Show and Tell" can be a time to bring out situational math (and other subjects). Some examples are comparing the number of steps wind-up toys make, the patterns of jewelry, weights of pets (Edwards, 1990), cost of share toys, the history of the items, and graphing who else in the classroom has these items. Deciding on a fair schedule for sharing can also be a good problem solving activity (Kamii, 1985).
Voting is a powerful activity which can be used for a variety of classroom situations. Democratic decision making helps develop social, moral and political development as well as intellectual development (Kamii, 1985). Situations that are appropriate for voting include choosing a group name, deciding on an activity, settling a dispute, and electing students for jobs (Kamii, 1985).

Door graphs related to the chosen theme are effective in making mathematics and the other subjects more meaningful. Door graphs provide a way for each student to express him/herself. Each graph is made from butcher or poster paper and is headed by a question related to the theme. It can be a yes/no question, such as "Do you own a pet?" or open-ended, such as "What kind of shoes are you wearing today?" Students can draw a picture or write their idea on a square of paper, depending on ability and content of question. Then students glue them on the door graph. Discussions can include categorizing answers, finding how many of each response and finding out the difference between responses (Reid & Martin, 1989).

Other daily situations which incorporate mathematics include: taking attendance, accounting for supplies, distributing things, opening books, planning for a party, limiting the number in a group, making a schedule, making calendars, talking about time (Kamii, 1985), counting lunch money,
logging time in and out of the bathroom (Kamii, 1989), and running a student store.

GAMES

Games should be a regular part of the curriculum; not just delegated as free-time activities for those who finish their work early. The 1987 *Math Model Curriculum Guide* recommends that students practice facts in a "variety of pleasant settings" (p. 4). Children can practice addition and subtraction in the context of structured play. They will think about and remember number combinations (Kamii, 1985). Math related games will help deemphasize procedural skills, as recommended in the *Standards* (Leonard & Tracy, May 1993).

Through games, students become involved in a positive mathematical environment (Leonard & Tracy, May 1993). When students play games, they interact with each other. They debate answers. This gives them more self-confidence, as they rely less on the teacher as the one with the right answer. Also, it helps them to have to think about their own processes of thinking (Kamii, 1985). Games can help build problem-solving abilities, as students apply mathematical knowledge to new situations (Leonard & Tracy, May 1993).

Games are also advantageous to the teacher. They can be made and reused for years. Teachers use the time during games to listen to and record
students' interactions which will help them gain insight to students' thinking.

This provides teachers with an informal diagnosis of student learning to provide
direction for further learning (Jones, December 1982).

Constance Kamii, in her books *Young Children Reinvent Mathematics*
(1985) and *Young Children Continue to Reinvent Mathematics* (1989), gives an
extensive annotated description of games which are appropriate for primary
grades. Listed here are a few of them:

- War- comparison of numbers
- Go Fish- logical thinking
- Concentration- Number recognition, addition
- Tic-Tac-Toe- Logical thinking
- Double War- Addition (Cards are placed two at a time and the winner
  is the one whose card total is highest)
- Fifty Chips- Addition (Students roll dice and place that amount of
  chips on their board with fifty squares. The first one to completely
  cover his/her gameboard is the winner. Variation: Double the
  amount on the die)
- Put and Take- exchange (A commercial game with chips which
  represent different values)
- Double Parcheesi- Addition (Double the amount rolled)
- Dominoes/ Even Dominoes- addition (Place a number down that
  would make the sum even)
- Tri-ominoes- Addition
- Sorry- Addition, problem solving

Listed here are some games that are also useful:

- Rack-o- Comparison, logical thinking
- Othello- Strategy
- Battleship- Graphing, strategy
- Checkers- Strategy
- Connect Four- Strategies
Teacher-made games can be equally effective in reinforcing skills and promoting problem-solving. Games can be designed to fit the thematic unit. Many educational publishing companies, such as Monday Morning Books, Inc., market generic gameboards with thematic designs. The teacher then designs the game and fills in game cards with questions pertaining to his/her specific learning objectives. Addition, counting, and thinking skills remain an integral part of these games.

INVESTIGATIONS

The Mathematics Framework recommends the usage of investigations as a powerful way to teach mathematics. Investigations challenge students to delve into a mathematical idea and generalize the results. This can be a culminating activity, which integrates what students have been learning, or a way to introduce a topic. Investigations may take more than a week to complete. Some examples of investigations are: "What is a fair way to ration water in a drought?", "How are actual measurements on clothes related to the sizes on their labels?", and "How much gasoline do all the cars in our town burn in a year?" (Mathematics Framework, 1992, p. 19). These kinds of questions allow for the integration of disciplines in a meaningful, problem-solving setting.
Topics for investigations may be provided by the teacher, or invented by the students and approved of by the teacher. Some suggested criteria for investigations include:

1) It is essential; it represents a major idea.
2) It is rich; it raises many questions.
3) It is open-ended.
4) It is authentic.
5) It is engaging and thought-provoking.
6) It is collaborative.
7) It is feasible in terms of time and safety (Collison, February 1993)

Baker, Semple and Stead (1990) recommend that whole-class explorations of a topic precede investigations. The explorations give students some topics for the investigations and provide skills needed to complete them. During investigations, teachers are encouraged to hold clinics for students who feel they are weak on a specific skill related to the topic. For example, during an investigation on time, the teacher may hold a clinic on how to tell time. Only those students who need it sign up for that clinic.

The problems for investigations may come from current events, experiments, student experiences or literature. Literature can be a springboard for investigations as well as a powerful tool to teach concepts across the curriculum.
MATHEMATICS AND LITERATURE

Mathematics and literature may appear at first to be totally unrelated (see figure 1). Yet, the purposes and functions of each are actually parallel to each other. Both have the function of ordering the world. Both are concerned with classification and problem solving. Relationships and patterns are examined by both. They both have aesthetic appeal (Griffiths & Clyne, 1988). Both focus on process (Thiessen & Matthias, ed., 1992). By linking the two, the understanding of both mathematics and literature can be more effective.

The use of literature fulfills the goals set in the Standards. The first goal is that children learn to value mathematics. Through books, children see people using mathematics for various purposes. They come to see that mathematics is a useful tool for solving problems and making decisions (Whitin, August 1992). Books help learners to see mathematics as an everyday activity, instead of as an artificial discipline. They provide a meaningful context for mathematics (Whitin & Wilde, 1992).

The second goal of the Standards is that students become confident in their ability to do mathematics. As literature encourages a positive attitude toward mathematics, it can relieve anxiety. Students can learn through a less threatening medium (Whitin & Wilde, 1992).
Figure 1: The Literary Qualities of Mathematics- One View

CALVIN AND HOBBS  copyright 1992 Watterson. Dist. by UNIVERSAL PRESS SYNDICATE. Reprinted with permission. All rights reserved.
The *Standards*' third goal is that students become mathematical problem solvers. Literature can present problems to be solved and also allow for the construction of related problems by the teacher or the student (Whitin & Wilde, 1992).

Goal four of the *Standards* is that students learn to communicate mathematically. It further states, "This is best accomplished in problem situations in which students have an opportunity to read, write, and discuss ideas in which the use of the language of mathematics becomes natural" (p. 6). Children's literature helps learners to do this by encouraging discussions about mathematics and the use of mathematical language (Whitin & Wilde, 1992).

The *Standards* agrees that "reading children's literature about mathematics... is also an important aspect of communication that needs more emphasis in the K-4 curriculum" (p. 26). Literature offers a purpose for learning and appreciating precise mathematical language (Griffith & Clyne, 1988).

The fifth goal of the *Standards* is that students learn to reason mathematically. Literature helps students develop number sense, such as meanings of numbers, relative magnitude of numbers, referents for measures of common objects, and the relative effect of operating on numbers (Whitin & Wilde, 1992). The *Standards* stresses the development of mathematical thinking by placing tasks within the familiar contexts of children. Research has
also found that context is important for the establishment of mathematical thinking (Donaldson, 1979, Hughes, 1986 in Griffiths & Clyne, 1988).

Literature gives a context which is both interesting and meaningful to children (Griffiths & Clyne, 1988).

Children learn mathematics through using language. It is important for young children to have experience with informal language and concrete representations before they begin to use the more formal language of mathematics (Clements, 1982, Labinowicz, 1985, Irons, 1985, Hughes, 1986 in Griffiths & Clyne, 1988). Books allow for opportunities for discussion and provide a structure and defined context within which children can explore, manipulate, and develop mathematical concepts (Griffiths & Clyne, 1988).

Literature can enhance the understanding of mathematics by:

- illustrating concepts
- posing problems
- directing investigations
- developing recording
- developing mathematical thinking
- stimulating independent thinking
- encouraging choice and decision-making
- extending the pleasure of literature (Griffiths & Clyne, 1988, p. 9-10)

Some literature books deal solely with mathematical concepts, whereas others have a concept which can be drawn out of the plot of the story. Some criteria for using literature books are:
1) Texts and illustrations should be accurate and mathematical ideas [as well as ideas from the other disciplines] should be portrayed correctly.
2) Illustrations should be attractive and appealing.
3) Illustrations should be appropriate in size and detail to the child.
4) Texts should be interesting and easily understandable (Harsh, September 1987).

Appendix I is a data base of literature books which can be used to teach mathematical concepts. The books are sorted by the theme for which they are appropriate, to aid the teacher in planning thematic units. Appendix II provides a list of reference books which give more information on these books and others.
ORGANIZATION OF THEMATIC UNITS

Before organizing and planning units, teachers need to focus on the purposes of teaching and the environment needed in order for learning to occur. With these goals in mind, teachers can then plan meaningful units which incorporate sound instructional practices and authentic assessment.

PURPOSES OF TEACHING

As discussed earlier in this project, the industrial-aged view of education is outdated and needs to be changed in order for the youth of today to successfully function within a technological society. Kovalik (1993) suggests that the following premises for teaching are outdated and should be discarded:

- All students learn the same.
- Yesterday's curriculum is good enough for today.
- Words create knowledge.
- Acquisition of knowledge and skills is the goal of education.
- Textbooks equal curriculum and instruction.
- Changing one aspect of the system is sufficient (p. x-xv).

Kovalik suggests the following list of new premises for teaching, which are consistent with the way children learn:

- The purpose of public education is the perpetuation of democracy.
- Real life is the best curriculum for children; the curriculum for the 21st century must be based on reality, not on "disciplines" and textbooks.
- Learning is a personal affair.
- Curriculum should consist entirely of concepts, skills, and attitudes/values which students can experience through being there.
- Instructional strategies should provide students choices which allow for their unique ways of learning.
- Curriculum should be framed so as to reduce "telling about" and be based on exploration, discovery, and application of concepts to the real world.
- Assessment should be reality-based (1993, p. xvi).

ENVIRONMENT

Both the physical and emotional climate of the classroom can make a difference in student learning. Some considerations of physical environment include providing space to allow for changes in grouping and movement and adequate materials for students to manipulate and use in investigations (Griffiths & Clyne, 1988). Also considerations of lighting, sounds (noise level, music), and general atmosphere should be taken into consideration.

The emotional climate of the classroom also needs to be conducive to learning. Children need to feel that their contributions are valued (Griffiths & Clyne, 1988), and there is absence of threat in the classroom (Kovalik, 1993). Students need to be able to work collaboratively and to be given adequate time to read, talk, do (experiment, investigate, discover), master and share (Griffiths & Clyne, 1988, Kovalik, 1993, Rhoades & McCabe, 1992). Students work in an enriched environment with appropriate challenges, choices, and timely, meaningful feedback (Griffiths & Clyne, 1988, Kovalik, 1993). It is also important to allow for emotion, creativity, and humor (Ohanian, October 1989).
Jaqueline Rhoades and Margaret McCabe (1992) describe the classroom as a place where there is a community of learners. Members of the community of learners are:

- Responsible citizens
- Self-Confident
- Initiators
- Self-Monitoring
- Nurturing and concerned about others
- Future-oriented
- Thinkers
- Problem Solvers
- Able to function successfully as individuals and as team members (p. 17)

There are four essential elements in creating a community of learners:

- Using interactive, cooperative learning assignments and tasks.
- Viewing the classroom as a meeting.
- Teaching and learning specific social and human interaction skills, such as successful communication processes, problem-solving and conflict management.
- Carefully integrating thinking skills development into daily curriculum (p. 17).

The premises for teaching and the considerations for classroom environment need to be at the foundation of every thematic unit. Teachers need to refresh themselves of these when starting to plan a new unit.
PLANNING A UNIT

The following steps are suggested when planning a thematic unit (they will be discussed in further detail):

1. Choose a theme appropriate for the class and grade level.
2. Gather available resources for this theme.
3. Choose the outcomes to focus on for this theme.
4. Choose the academic objectives appropriate for this theme.
5. Outline the unit's culminating activity.
6. Design lessons which will lead up to the culminating activity.
7. Design expanded opportunities.
8. List types of assessment to be used within the unit.
9. Design an evaluation for the unit (Adapted from Rhoades & McCabe, 1992, p. 18).

1. Choose a theme appropriate for the class and grade level.

The section on integration gives suggestions for possible themes which can be used. Teachers often have specific themes which they like to do at specific times of the year. An interest survey of the class can provide suggestions of themes the class would like to explore. Keep in mind that themes are not to be regarded as an end to themselves; they are merely vehicles for meaningful learning. Themes should cut across the curriculum. It is impossible to include every discipline in every thematic unit. Therefore teachers should consider the scheduling of units during the year to balance out the treatment of the various disciplines.
2. Gather available resources for this theme.

Appendices I and II give information on many available resources. Appendix I is a data base of books which can be used. The books are categorized first by theme, then by appropriate mathematics concepts which can be taught from each book. Appendix II provides a list of resource books which can give more suggestions on how to use these books effectively.

The classroom is an invaluable resource, as well as the classrooms of colleagues. Educational catalogs and stores are also good resources. Parents and community members are important sources of information which should not be overlooked.

Once sufficient resources have been gathered together, the ones which will be most effective in reaching the desired outcomes and academic objectives should be chosen.

3. Choose the outcomes to focus on for this theme.

Outcomes are not the same as academic objectives. Outcomes are goals which we want students to know, do, and be like, in order to function in society (Spady & Marshall, 1991 in Rhoades & McCabe, 1992). Seven major outcomes which have been defined by futurists and business leaders as essential qualities for survival now and in the future are:
When planning a unit, teachers need to choose which outcomes are feasible goals for that specific unit. These should play a prominent role in the design of lessons and the culminating activity. Appendix III contains behavioral indicators for exit outcomes adopted by the Fontana Unified School District, Fontana, California. No more than five or six behavioral indicators should be chosen per unit; otherwise the power of these outcomes becomes too diluted.

4. Choose the academic objectives appropriate for this theme.

Academic objectives are the content, skills, and processes to be taught within a unit. Objectives can be found within the Frameworks (see section on integration for K-3 objectives for English-language arts, history-social science, mathematics and science). Other sources for academic objectives include publications from national organizations, such as the National Council of Teachers of Mathematics, and from district curriculum guides.

As with the outcomes, it is important to not choose too many objectives. It is essential, however, that academic objectives be drawn from all disciplines which will be represented within the thematic unit.
5. Outline the unit's culminating activity.

A culminating activity is designed to pull together previous learning within the unit into a meaningful application by the student. Culminating activities should be creative, diverse, open-ended, and varied. Culminating activities include:

- Investigations
- Projects
- Reports
- Performances
- Inventions
- Experiments
- Letters

Culminating activities should be structured, so that students know what they are expected to accomplish, yet open-ended enough to allow for individuality and creativity. Rubrics can provide the structure needed, as well as assess the activity. An example of a rubric for a culminating activity can be found in Appendix V, which is a sample unit on nutrition.

6. Design lessons which will lead up to the culminating activity.

Lessons should be designed only after the specific outcomes, academic objectives, and culminating activity have been established. The lessons should be designed so that they provide the needed skills in order to complete the culminating activity and meet the designated outcomes and academic objectives.
for the unit. Although it is tempting to teach everything possible about a theme, extraneous lessons should be left out if they do not lead to the overall goals of the unit.

7. Design expanded opportunities.

Teachers need to provide expanded opportunities for students who need it in order to ensure that all students are successful. An expanded opportunity can maximize a student's learning potential if it is parallel with that student's unique learning style, thinking and reasoning style, and values and beliefs, and if it provides that student with realistic choices that lead to personal accomplishment (Rhoades & McCabe, 1992). Some examples of expanded opportunities are:

- Offering clinics, as mentioned earlier, which provide skills instruction on a need basis during a unit (Baker, Semple & Stead, 1990).
- Allowing students to negotiate time extensions on activities.
- Allowing students to delete some activities if they go into depth on another activity.
- Allowing alternate materials or alternate performance modes.
- Helping students to recognize and maximize their learning styles.
- Revisiting an outcome or academic objective in a later unit.
- Grouping students to balance the strengths needed to complete the activity successfully.
- Teaching and modeling each skill before students are required to perform the skill (Rhoades & McCabe, 1992).

Some of these expanded opportunities can be planned for in advance. Others can be used as the need becomes apparent.
8. List types of assessment to be used within the unit.

Assessment should be an ongoing part of instruction. The *Standards* states these criteria for assessment:

- student assessment [must] be integral to instruction,
- multiple means of assessment methods [must] be used,
- all aspects of mathematical knowledge and its connections [must] be assessed, and
- instruction and curriculum [must] be considered equally in judging the quality of a program (NCTM, 1989, p. 190).

It further specifies that the assessment of students' mathematical knowledge should show information about their:

- ability to apply their knowledge to solve problems within mathematics and in other disciplines;
- ability to use mathematical language to communicate ideas;
- ability to reason and analyze;
- knowledge and understanding of concepts and procedures;
- disposition toward mathematics;
- understanding of the nature of mathematics;
- integration of these aspects of mathematical knowledge (NCTM, 1989, p. 205).

From a cross-curricular perspective, Jacqueline Rhoades and Margaret McCabe (1992) describe six essential components of authentic assessment:

- *Performance based*- students are required to demonstrate learning of essential academic objectives in an activity directly embedded in exit outcomes.
- *Multi-faceted*- two or more assessment techniques are used.
-**Measured over time**- Multiple opportunities are offered students to revise and refine their efforts in order to develop patterns of thought which will extend beyond this one activity.

-**Criteria are clearly stated before beginning the assessment**- Students should clearly understand the standard of excellence before beginning the task.

-**More than one right answer**- The culminating unit activity is structured in an open-ended manner which allows students the opportunity to problem-solve and create their own solution.

-**Essential learning**- The assessment includes only items directly linked to exit outcomes and academic objectives that have been identified as essential to the student's ability to succeed in the global society (p. 55).

Different forms of assessment are needed to incorporate evaluations of all these aspects of student learning. Forms include:

- responses to open-ended questions, problems and tasks
- projects
- portfolios
- writings
- demonstrations
- presentations, discussions and debates
- investigations
- models and simulations (National Academy of Sciences, 1991, p. 15)
- photographs and video tapes (Edwards, 1990)
- observation
- individual conferences
- listening
- observing how a student gives feedback to another student
- observing how a student approaches a problem, what processes are used and personal qualities shown
- observing how a student interacts with others
- monitoring attendance at clinics
- monitoring sharing of projects
- self assessment by student (Baker, Semple & Stead, 1990, p. 89)
- rubrics [samples of these are in Appendix V] (Rhoades & McCabe, 1992)
questions about procedures
-focused written tasks
-directed test items
-written tests
-extended problem-solving projects
-take-home tests
-homework journals
-group work and projects
-standardized achievement tests (NCTM, 1989, p. 200-201)

The recordkeeping of assessment goes beyond the traditional gradebook. Assessments can be recorded in class checklists, annotated class or individual record sheets, portfolios and accompanying evaluation forms, rubrics (also called matrices), self-evaluation sheets, and photographs and video tapes.

The choice of the form of assessment and the type of recordkeeping used needs to be aligned with what the teacher is trying to measure. Also, students should be given the opportunity to make corrections until they have successfully completed the criteria for assessment.

9. Design an evaluation for the unit

At the end of each unit, teachers need to evaluate the unit so that any needed adjustments can be noted before this unit is used again (Rhoades & McCabe, 1992). Any changes in items 2-8 should be noted, with brief explanations.

Appendix IV contains sample forms for planning a unit. Appendix V contains a sample unit on nutrition.
FIELD TEST OF PROJECT

The project will be read and evaluated by several primary teachers. These teachers will fill out a questionnaire (in Appendix VI), evaluating the clarity, usefulness, practicality and effectiveness of the project; the ease with which the information and organizer were used; and suggestions for improving the project.

The project will also be implemented at a school in Southern California with a group of primary teachers. These teachers will be designing outcome-based thematic units. They will use the information provided in this project and the organizer to plan units which effectively integrate mathematics over the period of one school year. At the end of the year, they will evaluate the use of the information and organizer and give suggestions for improvements (see Appendix VI).

A third field test of the project will be through working intensively with one teacher for a year. The teacher will be guided through the year in the planning and implementation of mathematics taught in daily situations, games, literature, and thematic units. At the end of the year, this teacher will evaluate the success in teaching mathematics through these four learning opportunities (see Appendix VI).
IMPLICATIONS FOR TEACHING

This project is designed for primary teachers in California, as it follows the guidelines set forth in the Frameworks for California Public Schools in mathematics, English-language arts, science, and history-social science. Primary teachers from other states will find this project helpful. However, they will need to consult the guidelines for their state before implementing this project.

This project also gives teachers guidelines for teaching mathematics in a powerful, meaning-centered fashion. Teachers can also use this project to successfully integrate mathematics with other subjects so that students see the connections between disciplines.

These are the first steps towards creating students who will be ready to face the job world of the 21st century.
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APPENDIX II

REFERENCE LIST FOR LITERATURE RESOURCES


APPENDIX III

BEHAVIORAL INDICATORS FOR EXIT OUTCOMES

EFFECTIVE COMMUNICATORS

- Gets the listener's attention before speaking
- Looks at listener
- Claims own thoughts, ideas and feelings
- Is Clear - stick [sic] to one topic at a time
- Checks with listener to be sure message is clear
- Uses pronouns sparingly and correctly to avoid confusion
- Elaborates on the message if listener says she doesn't understand
- Uses visual cues to communicate message when appropriate
- Speaks concisely - communicates the main point of a message without excess and superfluous comments
- Is complete - makes sure all important details of the message are included
- Identifies feelings by name
- Uses appropriate nonverbal communication to send messages
- Nonverbal and verbal messages are congruent
- Provides verbal and nonverbal feedback
- Uses "I-Messages" in conflict or potential conflict situations
- Looks at the speaker
- Clarifies by asking questions
- Clarifies by paraphrasing
- Checks perceptions of speaker's feelings
- Listens to the whole person - verbal & nonverbal messages
- Sets aside own point of view when listening to make sure he understands speaker's meaning and intent
- Has developed strategies to communicate with others with different cognitive/learning styles
- Has developed strategies to communicate with other racial and ethnic groups
- Can teach others, is able to explain ideas and concepts that are new to the listener
- Can negotiate in a non-confrontive manner
- Can work with others on teams
- Can express precise and accurate information in writing
- Can clearly state her own point of view in a written message
- Can communicate in writing to a variety of audiences and for different purposes
- Can demonstrate the four domains of writing
- Is able to use a word processing program
- Is able to use computer search programs
- Is able to use modems and FAX machines
- Can communicate effectively on the telephone
- Understands the effect of nonverbal messages when speaking on the phone, e.g., smile carries through, so does frown

INSPIRED LEARNERS

- Actively participates in decision making
- Participates in long and short range planning
- Participates in strategic planning
- Uses the computer as a learning tool
- Uses a variety of problem solving strategies
- Is able to select an efficient problem-solving strategy to match the situation
- Makes life choices that ensure a healthy mind and body
- Actively seeks new information
- Has obtained a basic competence in reading, writing, listening, speaking and technological skills
- Has developed own criteria for assessing growth of own thinking and learning
- Takes risks with ideas
- Defines and pursues personal excellence
- Is aware of own learning style
- Is able to design an (advance) organizer for both school and personal life
- Has developed a wide range of learning strategies
- Initiates study in areas of interest and in areas where more knowledge is needed
- Takes responsibility for own learning
- Demonstrates enthusiasm for learning
- Wants to discuss differing points of view, different interpretations of content
- Demonstrates desire to continue learning after leaving school
- Recognizes that people learn from each other regardless of differences in age, ethnicity, gender, religion, etc.
- Places no limits on ability to learn
- Encourages others in and out of class
- Helps others to learn
- Is a cooperative learning team member

PRODUCTIVE WORKER

- Is punctual - arrives on time to meetings and personal appointments
- Balances work and personal life
- Participates in short and long-term planning
- Approaches change with a positive attitude
- Completes school and personal tasks in a timely manner
- Is able to turn conflicts into problems to be resolved
- Knows various problem solving strategies and select appropriate strategy for any given situation
- Is able to manage data on computer
- Is able to organize and plan time
- Is able to schedule assigned tasks
- Is responsible
- Recognizes mistakes and corrects them
- Interacts positively with co-workers, supervisors, subordinates, and consumers
- Is sociable
- Is a self-manager
- Has a clear definition of integrity
- Perseveres when presented with a difficult problem
- Treats others with respect
- Prioritizes tasks and activities according to life values
- Schedules priorities
- Establishes goals and objectives and designs action plan to accomplish
- Continues learning
- Is a cooperative team member
- Uses work skills to contribute to the community
- Helps others learn the job
- Participates in decision making
- Participates in short and long term planning
- Takes pride in her work
- Approaches change with a positive attitude
- Can adapt to new situations
GLOBAL CITIZEN

- Understands cultural diversity, ideas and practices
- Can participate in a culturally diverse social milieu
- Recognizes the socio-economic diversity present in the world today
- Can understand and speak more than one language fluently
- Recognizes own values
- Makes rational decisions based on own values
- Is aware of prevailing world conditions and developments
- Is aware of global change
- Understands that human beings have choices and the range of choices may be linked to socio-economic conditions
- Is open to differing perspectives
- Understands the relationship of systems such as air, land and water to world balance
- Understands that a variety of religions are practiced in the world and can discuss the major components of those that have the greatest impact on his culture
- Understands the impact on disease on populations throughout the world
- Is aware of the relationship of sports to culture
- Generates a sense of community with a selected population
- Views self in control of own destiny
- Understands ecological issues of concern in the world and takes steps to improve the situation
- Understands the connectiveness of nations
- Participates in any way possible to achieve and maintain peace in the world
- Respects other cultures
- Uses skills to contribute to the community
- Understands the interconnectedness of ecological, economic and technological spheres
- Is neither ethnocentric nor ethnohostile, recognizes value of own nation and others
- Nurtures own spiritual sphere of life

RESOURCEFUL THINKER

- Understands that many problems do not have a single right answer
- Is able to select essential facts from a field of information and apply to current situation
- Is able to participate in non-judgmental brainstorming
- Recognizes own cognitive style
- Can learn new behaviors by observing others
- Considers consequences of own actions
- Seeks activities that challenge the intellect and imagination
- Is able to transfer new learning outside the learning environment
- Is able to link two or more sets of information and perceive a relationship
- Is involved in metacognition
- Is aware of own types of intelligence
- Is able to organize thinking
- Is able to organize data using a variety of techniques
- Possess a variety of thinking strategies
- Can select and analyze data
- Can compare and contrast
- Can manage personal resources
- Can see things in the "mind's" eye
- Seeks new ideas
- Considers other's points of view
- Is a self-initiator
- Will try new ways of doing things
- Feels comfortable with uncertainty
- Understands written, oral and nonverbal messages
- Can follow written and oral directions
- Turns "failure" into a learning opportunity
- Waits before he acts
- Establishes goals then develops a strategic plan to accomplish the goals
- Studies the thought processes of others
- Demonstrates curiosity

APPENDIX IV
FORMS FOR UNIT ORGANIZER

Unit Title: 

Grade Level: 

Available Materials:

Books: 

Supplies: 

Exit Outcomes to be included in this unit: 


Academic Objectives:  


Culminating Activity:  


Expanded opportunities:  


Lesson Sequence:

Lesson 1:  

Lesson 2:  

Lesson 3:  

Lesson 4:  

Lesson 5:  

Lesson 6:  

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Lessons to teach before performing this lesson: __________________________

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Lesson: ______________________

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EVALUATION OF UNIT

1. Resources to add or delete before doing unit again: ________________

2. Outcomes to add or delete before doing unit again: ________________

3. Academic objectives to add or delete before doing unit again: ____________

4. Changes in culminating activity: ________________

5. Changes in lesson design: ________________
6. Changes in expanded opportunities: ________________________

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7. Changes in assessment: ________________________

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8. Additional comments: ________________________

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(These forms are adapted from Rhoades, J., & McCabe, M. (1992). 
Outcome-based learning: A teacher's guide to restructuring the classroom. 
APPENDIX V
SAMPLE THEMATIC UNIT

(NOTE: This unit does not contain all the lessons which would be done for this unit. It contains the main lessons which lead up to the culminating activity.)

Unit Title: Nutrition
Grade Level: 2-3
Available Materials:

Books: Gregory, The Terrible Eater
Cloudy, With a Chance of Meatballs
Strega Nona
Stone Soup

Supplies: Pictures of Food
Calculators
Magazines

Exit Outcomes to be included in this unit:

Inspired Learners:

- Makes life choices that ensure a healthy mind and body

- Participates in strategic planning
Productive Worker:
- Is a cooperative team member
- Recognizes mistakes and corrects them

Global Citizen:
- Makes rational decisions based on own values
- Is open to differing perspectives

Resourceful Thinker:
- Understands that many problems do not have a single right answer

Academic Objectives:
- Begins to practice the classification of objects according to similar characteristics
- Uses scientific knowledge to observe and describe daily life
- Uses charts to organize and calculate data
- Uses a calculator correctly to add
- Applies literature to personal experiences

Culminating Activity: Students will design a day's worth of meals which are healthy, and are balanced according to nutritional guidelines. Students will cut out pictures from magazines or draw pictures, as needed, and attach them to a pre-printed packet of meals. Students will categorize the foods by food group.
and total the food groups, ensuring that the nutritional requirements have been met.

Expanded Opportunities: Students who need it will be given the opportunity to redo the project, have a student tutor from a higher grade, provide calculator clinics, provide food group clinics.

Lesson Sequence:

Lesson 1: Classification of Food  
Lesson 2: Good Food vs. Junk Food  
Lesson 3: Fruit/Vegetable Face  
Lesson 4: Food Ads and the Four Food Groups  
Lesson 5: Weather Meals  
Lesson 6: Classification of Foods II
Lesson: 1 Title: Classification of Food

Lesson Activity: Students will work in groups of four to classify foods into groups and labels those groups.

Outcomes: Is a cooperative team member, is open to differing perspectives, understands that many problems do not have a single right answer

Academic Objectives: Students begin to practice classification of objects according to similar characteristics.

Assessment and Method: Teacher will observe the interactions of students, and give guidance as needed.

Students will present their groupings to the class. The class will give feedback on the reasonableness of the groupings.

Rubric (see next page).

Room Arrangement: Groups of four

Lessons to teach before performing this lesson: None

Lesson: Each group will be given a packet of cards depicting pictures of food from the four food groups. Students will sort them into four categories which the group agrees upon. Students will give a name to each category and present their classification system to the class.

Note: As this is the beginning of the unit, students will not be expected to correctly divide the cards into the four food groups.
Names

Categorization of Food Pictures

Content: YES  NO

Did your group divide the cards into four groups?

Did your group label each group of pictures?

Did your group clearly present their categories?

Social: YES  NO

Did everyone participate?

Did everyone work together in a friendly way?

Did everyone agree on the categories?

What were the names of the four categories you chose?

Teacher comments:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Lesson Activity: Students will bring in one label of a good food and one label of a junk food, and categorize them on a bulletin board.

Outcomes: Makes rational decisions based on own values

Academic Objectives: Students begin to practice classification of objects according to similar characteristics.

Assessment and Methods: Teacher observation.

Students will present their rationales to the class, as they hang up their pictures. Class and teacher will provide feedback and students may choose to change the placement of their labels.

Room Arrangement: Bulletin Board divided into two sections

Lessons to teach before performing this lesson: Read and discuss Gregory, The Terrible Eater, by Mitchell Sharmat

Lesson: Each student will bring in two label- one of a nutritious food and one of junk food. Each student will pin up his/her labels in the correct category and present the rationale to the class. The class will discuss the food choices.
Lesson: 3  Title: Fruit/Vegetable Face

Lesson Activity: Students will work in groups of four to predict, and subsequently find, the weight of fruits and vegetables in grams. Then students will design a funny face with the fruits and vegetables and draw a picture.

Outcomes: Is a cooperative team member, is open to differing perspectives.

Academic Objectives: Student begins to practice classification of fruits and vegetables, uses scientific knowledge to observe and describe daily life, uses charts to organize data.

Assessment and Methods: Teacher will observe and reteach balancing skills.

Student chart- will be checked for reasonableness of actual weights.

Room Arrangement: Students will be in groups of four. Each group will have one set of the fruit and vegetables for the group, and one balance with mass chips.

Lessons to teach before performing this lesson: Balancing items on a scale.

Lesson: Students will estimate the weight of each item individually and write the estimate on their chart. Then one student will weigh that item and all students will write the answer in their chart. This continues until all items have been weighed and charted. Then students will share the fruits and vegetables and individually make a face. Each student will draw a picture of his/her creation.
<table>
<thead>
<tr>
<th>Fruit/Vegetable to be weighed</th>
<th>Estimate</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 celery sticks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 cucumber slices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 banana slices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 apple slices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 raisins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 carrot sticks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 nuts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 grapes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A picture of my funny face:

Lesson: 4  Title:  Food Ads and the Four Food Groups

Lesson Activity: Students will work in groups of four to find the prices of foods in ads, classify these foods into the four food groups and add up the prices using the calculator.

Outcomes: Is a cooperative team member, recognizes mistakes and corrects them, understands that many problems do not have a single right answer

Academic Objectives: Student begins to practice classification of objects according to similar characteristics, uses charts to organize and calculate data, use a calculator correctly to add, apply literature to personal experiences

Assessment and Method: Completion of chart- Students will be given the opportunity to change choices that are not in the correct food group.

Room Arrangement: Groups of four

Lessons to teach before performing this lesson: The four food groups, use of calculators, the dollar and cent signs

Lesson: Each group will be given a chart (see next page), a calculator, and food ads. Each group will choose food items from the ads, place them correctly into the chart according to dollars and cents, and calculate the total. Each student in the group must add using the calculator, and all group members must agree to the total.
**Gregory's Shopping List**

Look in newspaper ads to find some nutritious foods for Gregory. Write the names of each food you choose in the correct food group. Then write in the price. Using a calculator, add up how much you spent. Each person in the group must add up the prices and you are not done until you all agree on the total.

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Name of Food</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Fruit</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Vegetable</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Vegetable</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Bread/Grain</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Bread/Grain</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td>$</td>
</tr>
</tbody>
</table>

**Total** $ .
Lesson: 5  Title: Weather Meals

Lesson Activity: Students will write stories about what precipitated out of the sky for breakfast, lunch and dinner, which incorporate appropriate weather words and categorize foods by breakfast, lunch and dinner.

Outcomes: Makes rational decisions based on own values, understands that many problems do not have a single right answer, is open to differing perspectives.

Academic Objectives: Students begin to practice classification of objects according to similar characteristics, apply literature to personal experiences, use scientific knowledge to observe and describe daily life

Assessment and Method: Rubric (see next page)- To be filled out by self, partner and teacher. After each part of the rubric is completed, the students will have the opportunity to make changes in their stories.

Room Arrangement: Groups of Two

Lessons to teach before performing this lesson: Read and discuss Cloudy With a Chance of Meatballs by Judi Barrett.

Lesson: Students will write a story, patterned after Cloudy With a Chance of Meatballs. Each story will classify foods by breakfast, lunch and dinner. Each story will use weather words which appropriately describe the food precipitating out of the sky.
Name of Writer ____________________________ Name of Partner ____________________________

Cloudy With a Chance of Meatballs

Read the story and circle the appropriate choice:

Your Evaluation

1. Did the foods fit each meal?  All  Most  Some  None
2. Did the weather words fit each food?  All  Most  Some  None

Your Partner:

1. Did the foods fit each meal?  All  Most  Some  None
2. Did the weather words fit each food?  All  Most  Some  None
3. Have you eaten these foods?  All  Most  Some  None
4. List any foods you eat at a different meal than was in the story and tell what meal you would eat them at: __________________________________________________________

Teacher:

1. Did the foods fit each meal?  All  Most  Some  None
2. Did the weather words fit each food?  All  Most  Some  None
3. Teacher comments: ______________________________________________________________


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Lesson:  6  Title:  Classification of Foods II

Lesson Activity:  Students will work in groups of four to categorize pictures of foods into the four food groups and extra (junk) foods.

Outcomes:  Makes life choices that ensure a healthy mind and body, is a cooperative team member, recognizes mistakes and corrects them.

Academic Objectives:  Students classify objects according to similar characteristics.

Assessment and Method:  Teacher observation.  Teacher will check and have students correct, if necessary.

Room Arrangement:  Groups of Four

Lessons to teach before performing this lesson:  Extra Foods

Lesson:  Students will classify pictures of food into the four food groups and extra foods.
Culminating Activity: My Balanced Meals Book

Lesson Activity: Students will design a day's worth of meals which are healthy, and are balanced according to nutritional guidelines. Students will cut out pictures from magazines or draw pictures, as needed, and attach them to a pre-printed packet of meals. Students will categorize the foods by food group and total the food groups, ensuring that the nutritional requirements have been met.

Outcomes: The culminating activity tries to pull together all of the outcomes from the previous lessons as much as possible.

Academic objectives: The culminating activity tries to pull together all of the objectives from the previous lessons as much as possible.

Assessment and Method: Students will accurately categorize food chosen.

Room Arrangement: Students will be working on individual books, but need to be able to share magazines.
Name ___________________________________ MY BALANCED MEALS

For each meal, list the foods you have chosen and check off what food group each belongs in. Total each food group for the day. You need to have: milk group- 3, meat group- 2, bread group- 4, fruit/vegetable group- 4.

<table>
<thead>
<tr>
<th>Meal</th>
<th>Name of food</th>
<th>Milk (3 total)</th>
<th>Meat (2 total)</th>
<th>Bread (4 total)</th>
<th>Fruit/Veg (4 total)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breakfast</td>
<td></td>
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<td></td>
<td>Breakfast</td>
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<td>Breakfast</td>
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<td></td>
<td>Lunch</td>
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<td>Lunch</td>
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<tr>
<td></td>
<td>Dinner</td>
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<td>Dinner</td>
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<td></td>
<td>Dinner</td>
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</tbody>
</table>

Total ____________________________
EVALUATION OF UNIT

1. Resources to add or delete before doing unit again: I would add some AIMS activities for each food group.

2. Outcomes to add or delete before doing unit again: None

3. Academic objectives to add or delete before doing unit again: Ones which fit in with the AIMS activities.

4. Changes in culminating activity: Do as partners next time, or have a partner check before the teacher checks.

5. Changes in lesson design: Add AIMS activities. Add more lessons on nutritional requirements.

6. Changes in expanded opportunities: Allow for more time on culminating project.

7. Changes in assessment: Change the language on some of the rubrics.

8. Additional comments:
APPENDIX VI

QUESTIONNAIRES FOR FIELD TEST

Questionnaire- Evaluation of Master's Project

After reading the project, please comments on these areas about the project:

1. Clarity of the project

2. Usefulness of the information to your current teaching position

3. Practicality if you used it in your classroom

4. Effectiveness in the teaching of mathematics

5. If you have used the information and organizer, please comment on how user-friendly it was.

6. Suggestions for improving the project

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Questionnaire- Organizer

After having used the organizer for one year, please comment on the following:

1. How much of the information in the project describing how to design a thematic unit did you apply to your classroom this year? 

2. How effective were the learning opportunities you designed in your classroom? 

3. Please give an suggestions on how the organizer can be improved to maximize use and effectiveness. 

4. Would you continue to use the organizer next year? 

5. How has this project changed how you teach mathematics? 

Questionnaire- One Year Evaluation

After working intensively on implementing the four learning opportunities with guidance, please comment on the following areas:

1. What daily situations did you use to teach mathematics, and how effective were they?

2. How did the use of games in the classroom affect the achievement of your class in mathematics?

3. How did you use literature to teach mathematics, and how successful was it?

4. How effective was the teaching of mathematics through thematic units?

5. How often did you use the organizer to plan thematic units?
BIBLIOGRAPHY


