Manipulative materials in mathematics instruction: Addressing teacher reluctance

Virginia Mae Johnson

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MANIPULATIVE MATERIALS IN MATHEMATICS INSTRUCTION:
ADDRESSING TEACHER RELUCTANCE

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

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

by
Virginia Mae Johnson
September 1993
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ABSTRACT

Manipulative Materials in Mathematics Instruction: Addressing Teacher Reluctance

Virginia M. Johnson, M.A.
California State University, San Bernardino, 1993

Statement of the Problem

The purpose of this project was to examine the areas identified by elementary school teachers as barriers to the implementation of the systematic use of manipulative materials in mathematics instruction. This inclination is evidenced in spite of a growing body of data supporting the efficacy of such strategies. Once these defenses were surveyed, a plan was designed to assist educators in the confrontation of these reluctances.

Procedure

The learning theories of Jean Piaget, Zoltan Dienes, and Jerome Bruner were examined as a basis for understanding the value of including the use of concrete objects in mathematics instruction. In addition, journal articles, research reports, and other relevant literature sources were explored, specifically in the area of beneficial outcomes of manipulative instruction.
The areas of reluctance that were identified were: children's tendency to "play" with the objects, pressures from parents and administrators to complete textbooks, inadequate supplies or resources for manipulatives, difficulties in assessing discovery lessons, and insufficient training on the effective use of manipulatives in mathematics instruction.

Based upon the review of the literature, this writer developed a curriculum guide to be used as a supplement to the inservice training of teachers in efficient manipulative use, specifically addressing the recognized areas. This guide includes: a theoretical basis for effective inservice workshops; guidelines, ground rules, and possible format presentations for use in the classroom; the importance of the inclusion of play; atypical suggestions for obtaining materials; alternative assessment activities; surveys and questionnaires for acquiring participant input; and an outline of content topics which may be included as indicated by needs assessment data.

Conclusions and Implications
Although the obstacles that were recognized and acknowledged as barriers to teacher implementation of
manipulative mathematics instruction were relatively uncomplicated to meet, there emerged a hurdle of greater complexity. Pilot implementation of the guide revealed that teachers' attitudes toward making changes came to the surface as perhaps the greatest hindrance to realizing long-term modifications in the way that mathematics is taught in America's elementary schools. It is this writer's opinion that generating the desire on the part of classroom teachers to make education a life-long endeavor is one area which warrants effort and energy, as well as further study.
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INTRODUCTION

Much consideration has been given to the benefits of hands-on activities in mathematics instruction, especially in the elementary school grades. Researchers in mathematics education (Bledsoe, Purser, & Frantz, 1974; Colgram, 1991; Post, 1980; Raphael & Wahlstrom, 1989; Sowell, 1989; Suydam & Higgins, 1977; Thompson, 1991) are continuing to add to the persuasive body of data that supports the inclusion of manipulative materials in the elementary classroom. Yet, in spite of this supportive data, many classroom teachers are not including the use of manipulative materials in their methodology for teaching mathematical concepts (Gilbert & Bush, 1988; VanDevender, 1988; Wiebe, 1981). Among the reasons given for this omission are: inadequate supply of materials, inadequate preparation on implementation methods, the students just "play" with the objects, lack of time for instruction, and concerns about management and control in the classroom (Anderson, 1978; Kutz, 1977; Post, 1980; VanDevender, 1988; Yeatts, 1989). Regardless of the reason cited, the fact remains that teachers, and consequently
students, are not using developmentally appropriate materials in mathematics instruction (Yeatts, 1989).

The notion that there is a significant correlation between the use of manipulative materials in the classroom and achievement in mathematics is widely accepted among educators (Bledsoe, Purser, & Frantz, 1974; Colgram, 1991; Prigge, 1978; Raphael & Wahlstrom, 1989; Sowell, 1989; Suydam & Higgins, 1977; Thompson, 1991). Learning theorists have proposed for a number of years that children learn abstract concepts such as mathematics through direct interaction or "manipulation" of physical objects in their environment.

In 1971, Jean Piaget developed prescribed stages of intellectual formation and how they relate to cognition. His well-known stages of intellectual development emphasize the fact that children are different from adults in thought, language, and action in both quality and quantity. He proposed that children, especially young ones, learn best from concrete activities.

Jerome Bruner (1960), who was greatly influenced by the work of Piaget, suggested that students should be developers of information rather than merely receivers. To accomplish this shift in learning
philosophy, he suggested that learning readiness depends on a mix of direct experience, the use of visual aids, and the abstract symbols that represent reality.

Zoltan Dienes (1969) considered mathematics learning to be a process which evolves as children are exposed to activities that provide them with direct interaction with their environment.

In addition to the work of Dienes, research dealing with the impact of hands-on instruction on the learning of mathematics concepts is extensive. More than twenty reviews of such research have been completed since 1957. In one comprehensive review compiled at the Mathematics and Science Information Reference Center at Ohio State University by Suydam and Higgins in 1976, it is indicated that sixty percent of the research studies examined favored the manipulative usage, while only ten percent clearly favored the nonmanipulative treatment.

In addition, researchers in mathematics education have confronted the issue of teacher omission of manipulatives in their math methodology. Surveys have indicated that only fifty-three percent (Fey, 1979) and forty-two percent (Gilbert & Bush, 1988) of the nation’s mathematics classes, kindergarten through grade six, use materials to enhance mathematics lessons
more than once a week. Research further indicated that fewer than twenty-two percent of teachers use manipulative materials more than five times a year (Scott, 1983). This is a particularly small quantity if the finding of Weibe (1981) is considered. He suggested that reported use of materials is often less than actual utilization.

The project resulting from the examination of the data from professional journal articles, other literature and research, will, in consideration of these findings and conclusions, answer the following questions: 1) what are the obstacles to utilization of manipulative materials on an on-going basis in the classroom, and 2) what is a course of action that will address the points of concern on the part of the reluctant teachers?

Definition of Terms

For the purposes of this project, the terms manipulatives and manipulative mathematics materials are synonymous and refer to concrete objects which can be maneuvered and handled in the course of mathematics instruction. These may include, but are not limited to: popsicle sticks, beans, coins, counters, geoboards, seeds, shells, unifix cubes, pattern blocks, base ten blocks, cuisenaire rods, tangrams, and bean sticks.
References to "manipulation" of objects refers not to a mindless external act, but as Piaget (1952) suggests, to mental action which is accompanied by physical action. As a point of clarification, the use of concrete materials in mathematics instruction does not mandate that pencil-paper activities be eliminated from the curriculum entirely. Appropriate uses for workbooks, worksheets, and other symbolic activities can be determined. However, the use of these procedures should be restricted considerably in the early grades, simply because the children have not reached the developmental level where symbolic activities are beneficial (Post, 1980).
REVIEW OF PERTINENT LITERATURE

This literature review will:

A. Provide a historical perspective from which the consideration of the systematic use of manipulative objects in mathematics instruction surfaced as an element of importance.

B. Examine associated trends in modern curriculum reform.

C. Explore cognitive learning theories that are relative to the learning of mathematics concepts: the theories of Jean Piaget, Zoltan Dienes, and Jerome Bruner, and Lev Vygotsky.

D. Explain the components of effective mathematics instruction through a synthesis of theories currently accepted as valid.

E. Examine journal articles, other literature and research in the area of manipulative mathematics, specifically in the area of the beneficial effects of using concrete objects for concept instruction.

F. Determine the reasons for teacher reluctance to the utilization of manipulatives as the basic means for teaching mathematical concepts by examining research already completed.

G. Develop a theoretical basis for addressing these reasons by examining the components of change
theory, as well as research data relating to the specific areas of reluctance.

This literature review will establish the nature of necessary mathematics instruction for maximum learning, disclose obstacles for implementation of such instruction, and provide suggestions for removal of these obstacles.

Historical Perspective

Beginning long before the outburst of public concern in the 1950's, apprehension about achievement in math by the nation's students had been evident for several decades (Stanic, 1986). It is believed, however, that when the Russians sent the first Sputnik into space, the shock of this evidence of Russia's "superiority" in technology accelerated changes in school curriculum (Reys, 1989). This belief is deeply rooted and has become unextinguishable as one that explains the reforms in educational curricula. There is evidence that, while Americans were stunned by the indication that other countries in the world were equally competent in technological areas, Sputnik's main effect was to accelerate developments already underway, provoking much public support, as well as much additional federal funding (Jennings, 1967). It is maintained that the University of Illinois Committee
on School Mathematics began revisions of high school mathematics curriculum in 1952, stimulated by the realities of the culture and environment of the day (Silberman, 1970). Nonetheless, the fact remains that Sputnik did raise the awareness of the public sector with regard to school achievement and curriculum, leading to curriculum reform (Jennings, 1967).

The "new math" of the 1950's and 1960's ensued, and millions of dollars, along with widespread interest and effort, were invested in strengthening mathematics and science programs in the schools across the nation (Reys, 1989).

Also at this time, emphasis in mathematics education shifted from that of social utility to one favoring more technological content. Not only was additional content to be taught at the elementary level, but established concepts were introduced at earlier grade levels (VanDevender, 1988). Accompanying these changes, promises of more and better mathematical achievement emanated (Reys, 1989).

When these promises had not fully materialized by the beginning of the 1970's, there was another shift in curricular emphasis. Returning to the emphasis of the 1920's, significance was to be placed on skills needed for "survival" in the real world. This change in
significance occurred in response to declines in Scholastic Aptitude scores, low scores in parts of the National Assessment of Educational Progress, and lower achievement indicated by scores on state assessment tests. The mid 1970's brought a de-emphasis on understanding, new content, and innovative methods that had been in place since the 1950's (Ashworth, 1990). And although the resulting back-to-basics movement was a logical continuation of the effort to make teachers and schools accountable for children's learning (Reys, 1989), this represented a potentially "dangerous narrowing" of the mathematics curriculum to some mathematics educators (Stanic, 1986).

Since 1973, improvements in mathematics achievement are modest and are seen mainly in the lower-level skills and basic concepts usually taught in elementary school (Stanic, 1986). Although national trends for nine-year olds indicate significant improvements in math proficiency between 1978 and 1986, the National Assessment of Educational Progress assessments indicate that there are obvious disparities between the level of mathematics taught in school and student performance levels (Ashworth, 1990). As in previous years, the Gallup Poll of the Public's Attitudes Toward Public Schools twenty-first public
opinion poll indicates that concern on the part of the public still persists regarding poor curriculum and/or poor standards in the nation's public schools (Elam & Gallup, 1989). Changes in curriculum continue today because the content and skills that are needed in order to meet societal changes are diverse. In addition, new evidence about contemporary teaching approaches is continuously being established (Reys, 1989).

Modern Curriculum Reform

Although the push to improve the achievement in mathematics of the nation's students remains, the motivating influence seems to have shifted from one of high test scores to that of increasing the level of performance in skills related to effective functioning in society. In response to calls from the President of the United States, the nation's governors, professional mathematics organizations, as well as teachers and mathematics educators; curricular reform movements have emerged.

The state of California began development of its Mathematics Framework in October of 1988 to change three primary areas in mathematics education: What mathematics is being taught, how it is being taught, and to whom it is being taught. This cooperative effort expresses the need for fostering a deeper level
of understanding of the central ideas in mathematics. It also promotes changes in instructional methods from those of dispensing subject matter to emphasis on formulating and solving problems (Mathematics Framework, 1991).

Although the motivating purpose for such changes has been modified, there continues to be a demand for greater student achievement. In order to include the additional content and processes in the present curriculum, it is often necessary to teach more concepts to younger children (Reys, 1989). This arbitrary "stepping up" of the curriculum is in conflict with the accepted theories in child development which regard the cognitive development of children as sequential and correlating to stages of growth (Post, 1980).

Theories of Intelligence

Learning theorists have proposed that the emergence of intelligence is a process, the evolution of newer and more complex mental structures (Post, 1980). They also propose that the element of readiness for learning is an important factor in predicting achievement (Bruner, 1963; Piaget, 1971).

Jean Piaget

Piaget's formal stages of intellectual development
further portray the importance of recognizing the growth of intelligence as a process. He separates this process into four distinct stages: sensori-motor, pre-operational, concrete operational, and formal operational.

Piaget's sensori-motor stage is a pre-verbal, pre-symbolic stage from birth to about one and one-half or two years of age. It is characterized by direct action with the environment. Here the actions are first uncoordinated, gradually moving to deliberate actions, and, at the end of this stage, these actions are made to accomplish an objective (Piaget, 1971).

The pre-operational stage is from about two to seven years of age, although with normal developmental variations, it can begin as early as one year of age, and extend until nine or ten years of age. This is a stage of symbolism or representation, where words are used to represent things. During this stage, the child begins to manipulate or control these symbols, leading to the understanding of the cause-and-effect relationship. At this stage, the development of "semi-logical" reasoning begins, but since the child cannot reverse the reasoning process, pure logic cannot exist. (Copeland, 1984).

The concrete operational stage covers the ages
from seven to about eleven or twelve. This stage, includes the beginning of logico-mathematical thought that is based, in part, on the child's physical interaction and manipulation of real objects that simulate real-life experiences (Copeland, 1984).

The last of Piaget's stages, the formal operational stage, begins at eleven or twelve and continues throughout adulthood. At this stage, the individual is able to reason or hypothesize with ideas symbols, and has progressed past the need for manipulation of objects (Piaget, 1971).

The age at which children progress through these stages is influenced by factors such as physiological maturation, degree of meaningful social and educational interactions, and the quality of relevant intellectual and psychological experiences (Post, 1980).

Piaget emphasizes the role that social interaction plays in the rate at which intelligence develops, and the quality of that growth. He believes that social exchanges allow children to evaluate their own ideas and those of others, continually modifying internal structures as a result of the new experiences, and thus, encouraging the diminution of egocentricity. This process leads to a more realistic and more critical view of themselves and others (Piaget, 1971).
Jerome Bruner

Jerome Bruner created his own instructional model of the general nature of cognition. It included four components: structure, readiness, intuition, and motivation. Bruner felt that teaching students the structure as they study a particular concept leads to an active interest as they discover the basic principles for themselves. His key to readiness for learning is the child's intellectual development, or how children view the world around them. Intuitive thinking is an essential feature of productive thinking, one involving the training of hunches. He believes that children can learn anything if they first understand them intuitively, and then have a chance to try them on their own. Bruner's theory includes the position that motivation, or the desire to learn can be stimulated by merely providing activities in which the child has an interest. In doing so, learning creates its own excitement and provides its own reward (Bruner, 1960).

Zoltan Dienes

Although Zoltan Dienes confined his efforts to mathematics learning, application of his philosophy of learning spans the curriculum. He considered mathematics to be an art form, one to be studied for
the intrinsic value of the subject itself, and rejected utilitarian purposes (Dienes, 1971). He also proposed that learning mathematics should ultimately be integrated into one's personality and provide a mode of true personal satisfaction (Post, 1980).

Motivated by his concerns about the restrictive scope of subject content, the narrow focus of program objectives, the overuse of large-group instruction, and limited diversity of classroom instructional methods, Dienes developed what is referred to as the "Learning Cycle" (Dienes, 1971). This cycle, also designated the "Dynamic Principle", stated that genuine understanding of an unknown concept is a progressive process affecting the learner in three ordered, identifiable stages. The first period begins with the preliminary or play stage, which involves unstructured exposure to mathematical concepts. This is followed by an interval during which more structured activities are appropriate. That stage is finally replaced by the rise of the mathematics concept, complete with the facility for application to the child's real world (Post, 1980). Awareness of these successive phases and the corresponding developmental components is vital in teaching for genuine understanding of mathematical concepts.
Lev Vygotsky

The Russian psychologist, Lev Vygotsky, studied the development of concept formation in children. He named two basic forms of children's experiences, yielding two connected types of concepts: the scientific and the spontaneous (Kozulin, 1989).

According to Vygotsky, scientific understandings originate in the highly structured activities in classroom instruction. These concepts are presented to a child and are logical in nature (Vygotsky, 1934).

On the other hand, spontaneous concepts are those which emerge from the child's own reflections on his experiences of everyday life. These two concept types connect only after the child's general comprehensive ability is put into play. The scientific notions work their way to greater abstractness, while the spontaneous understandings move toward increased concreteness (Vygotsky, 1934). It is the balance and interplay of these two classes of concepts that prevent educational experiences from becoming one-sided (Kozulin, 1989).

Vygotsky further developed the notion concerning the dialogical character of learning. He proposed that concept formation in children is achieved as they interact verbally with adults. According to Vygotsky
such exchanges provide gauges of the child's intellectual abilities that are much more accurate.

The term zo-ped was used by Vygotsky (1934) to characterize this process. Zo-ped is defined as the "zone of proximal development". It is where the child's experientially rich, but unsystematic, comprehensions "meet" the logical, organized reasoning of the adult. The end result of this meeting of child and adult is an internalized, integrated solution that is part of the child's own thinking (Kozulin, 1989).

**Synthesis of Theories**

Hence, in examining learning theories, a thread of commonality emerges in which intellectual development can be summarized as an individual process, beginning when the child has achieved a sufficient level of readiness, commencing with simple perceptions, building on personal experiences, and developing into the comprehension of increasingly complex, abstract concepts.

However, there are a number of limitations in the thinking of children that distinguish their learning process from that of adults. Children have egocentric outlooks, are unable to generalize and reverse thought processes, and need concrete materials to provide an experiential basis for learning (Copeland, 1984).
According to Piaget and Bruner, solutions for problems and generalizations result from the students' own actions on their environments, and from their own mental operations (Piaget, 1952; Bruner, 1960). Vygotsky further includes adult-child dialogue as an essential component of learning (Vygotsky, 1934).

A lack of sufficient concrete experiences that are necessary to reach abstraction is considered by some to be the basic cause of failure in school. (Copeland, 1984). The preferred mode of providing these physical encounters is the inclusion of activities that produce direct interaction with concrete objects that are more abstract than the actual situation, yet less abstract than symbols (Post, 1980).

Concrete Objects

The notion of using concrete objects to assist children in the learning process did not originate with the learning theories of Piaget, Bruner, and Dienes. In Roger Ascham's, The Scholemaster, written in 1570, he encourages "teaching by cogent example and practical exercise rather than rote memorization" (Ryan, 1963, p. 251). William J. Milne's "Elements of Arithmetic", published in 1893, recommended extensive use of manipulatives such as splints, or counters, buttons, beans, or beads (Deatsman, 1976). Also in the
nineteenth century, their use was advocated by Pestalozzi, and of course the activity curricula of the early twentieth century encouraged their inclusion (Sowell, 1989).

More recently, educational research has supported the ideas of learning theorists and notions of mathematics educators regarding the benefit of including the use of concrete objects in mathematics methodology. Many studies indicate that lessons using manipulative materials have a higher probability of producing greater math achievement than do non-manipulative lessons for students both at the elementary school level (Anderson, 1978; Post, 1980; Prigge, 1978; Sowell, 1989; Suydam & Higgins, 1976 and 1977), and in junior high (Bledsoe, Pruser, & Frantz, 1974; Raphael & Wahlstrom, 1989). Several additional studies indicate that children benefit from concrete activities in conjunction with pictorial and/or symbolic exercises (Driscoll, 1981 and 1984; Fennema, 1972; Fey, 1979; Osborne & Nibbelink, 1976; Parnham, 1983; Suydam, 1984).

Perhaps the most recent and comprehensive review of research on the use of manipulative materials was gathered at the Mathematics and Science Information Reference Center at Ohio State University (Suydam &
Higgins, 1976). In this evaluation, it was concluded that manipulative materials are operative at lower grade levels, as well as higher levels. The authors further stated that in ninety percent of the studies that they reviewed, the use of manipulative materials resulted in commensurate or superior performance from the students when compared with nonmanipulative strategies.

In light of this convincing data along with attention given in professional journals, one might conclude that sufficient correlation has been established between the use of manipulative materials in mathematics instruction and increased student performance. This belief appears to be widely accepted in the educational community, but the belief is not always translated into action (Suydam & Higgins, 1976). The use of concrete materials by teachers in mathematics instruction appears to have remained moderately fixed (Kutz, 1977; Yeatts, 1989). It is reported that, depending on the grade involved, between 40.8 and 74.7 percent of the teachers surveyed used manipulative materials three times a week or less (Gilbert & Bush, 1988).

It is frequently reported by teachers that materials are available, but it is incongruously
reported that the availability impedes the teacher's increased use (Wiebe, 1981; Yeatts, 1989). It would appear that the availability factor is, at best, questionable.

Obstacles To The Use of Manipulative Materials

In an attempt to further analyze obstacles to the use of manipulative materials in addition to the teachers' responses reported above, a search was made of the available data regarding the perceived barriers. In one study, ninety percent of the teachers agreed that the need for more manipulative materials was a problem (VanDevender, 1988). Other barriers indicated in additional studies were:

1) Children "play" with them, resulting in wasted time;
2) Pressures to complete text material, to cut frills and get back to basics;
3) Lack of financial resources for purchase of materials;
4) Assessment difficulties;
5) Problems in classroom management and control: such as insufficient class time and preparation time; and
6) Professional preparation was not adequate to allow integration into their teaching methodology, making it more difficult to prepare for than text material; (Yeatts, 1989; Kutz, 1977; Post, 1980; Gilbert & Bush,
In order to secure information that would enable the amelioration of the elements of reluctance to use manipulative materials in mathematics instruction, an examination of related research and literature is indicated.

**The Children "Just Play" With the Objects**

Playing with the objects used in manipulative mathematics instruction is considered by some teachers to be problematic. Play is often considered to be wasted time, but it is an essential part of the process of growth in the life of a child.

It is proposed that there are two kinds of play: manipulative and representational. During manipulative play, the child tries to discover how the material handles. The mathematic "tool" is being explored, and its attributes are being assessed. In representational play, the imagination of the child is added to the manipulation and all sorts of scenarios are created in which the materials are used to represent ideas. It is when these two types of play merge, that the child has developed the mode for investigation and problem solving (Dienes, 1967).

In 1967, the Parliamentary Commission's Central Advisory Council for Education, also referred to as
the "Plowden Commission", released its report which stated that play is the principal way that young children learn. They further stated that it is the manner through which children adjust their inner natures with the reality of their environment. It is also the way in which the concepts of cause-and-effect, analysis, synthesis, imagination, solution formulation are generated (Silberman, 1970).

It is because of this significant function that play should be regarded as an indispensable part of any learning process. Therefore, it would appear that the inclusion of the "free play" dimension of the manipulative mathematics philosophy is congruent with theoretical constructs.

**Outside Pressures**

The obstacles of pressures from administrators or parents to complete materials and cut out inessentials are evidenced in a number of studies (Anderson, 1978; Gilbert & Bush, 1988; Kutz, 1977; Post, 1980). These appear to be circumstances that can be altered only through the gradual implementation of educational philosophy on the part of school administrators, school boards, and the public, in general (Post, 1980). Perhaps a preliminary step would include the in-service training of administrators regarding effective

The State of California Department of Education has published "The Changing Mathematics Curriculum: A Booklet for Parents." This is an excellent resource for parent education with regard to changes in mathematics curriculum and instruction.

**Inadequate Financial Resources**

The lack of financial resources for purchase of concrete materials was corroborated in several studies, along with the belief that such materials were too costly to be provided for individual classrooms (Anderson, 1978; Gilbert & Bush, 1988; Kutz, 1977; Post, 1980). Once again, it may be an issue of setting priorities, this time for budget items, which is often beyond the teacher’s control (VanDevender, 1988). Another possible solution to this dilemma relates to the expected quality of the concrete materials. For example, wooden craft sticks, beans, buttons, and other easily accessible and inexpensive items can effectively be used in place of commercial objects, with identical results (Anderson, 1978).
Assessment and Evaluation Difficulties

In recent years, apprehension has risen concerning the use of manipulative materials in mathematics instruction and the resulting difficulty in the assessment of student understanding. The traditional modes of evaluation often measure the student's ability to calculate and manipulate numbers in memorized algorithms instead of appraising comprehension and application proficiency based on concept understanding (Romberg, Zarinnia, & Collins, 1990).

In order to establish a theoretical basis for assessment, it is necessary to determine a working definition. For the purpose of this paper, assessment is the "comprehensive accounting" of the performance of a student or group of students (Webb, 1993).

Traditionally, the recognized reasons for assessing student learning are: conveying expectations to students, administrators, and parents; improving instruction and programs; monitoring the status of individuals, classes, districts, states, and the nation; and accountability (Raizen & Kaser, 1989). Current assessments were designed for the world view that grew out of machine-age thinking during the industrial revolution (Romberg et al., 1990).
The intellectual themes of the machine age were based on three central ideas: reductionism, or the taking apart of anything until its simplest parts are identified; analysis, involving the breaking down of a problem into its component parts, then building it up again; and mechanism, the conviction that everything can be explained by cause-and-effect relationships. The ensuing curricula and assessment processes reflect the physical perspective in which work [including school work] was viewed (Romberg et al., 1990).

The influence of these themes is revealed in elementary school mathematics instruction. These subjects have been divided first into subjects and topics, and then down to their smallest parts—behavioral objectives. From there, a sequential process of learning was constructed to rebuild these components into finished concepts. Next, the learning process was "mechanized" through the use of worksheets, textbooks, and tests (Romberg et al., 1990).

The shift from an industrial society to one based on the transfer and understanding of information has altered the prevailing world view, resulting in the necessity of new approaches to educational assessment (Romberg et al, 1990). In order to accommodate the shift in desired outcomes, old and new expectations
must be analyzed, and the assessment tools that are no longer appropriate, discarded (Romberg et al., 1990). These can then be replaced with procedures that are consistent with new curriculum goals and changing world views.

In the assessment of the understanding of mathematics concepts, the de-emphasis of drills and skills has been advocated, as has a decrease in teacher-presented material. These activities might be replaced by investigations that teach children to communicate, solve problems, interpret, reason, and to apply their ideas in creative ways (Redding, 1992).

Ideas for alternative assessment have been urged for many years, but have not been implemented because the encountered difficulties are not easily overcome. According to Lambdin (1993), assessment methods that are unconventional are often difficult to devise and effect. Secondly, the data resulting from alternative assessment activities is more difficult to systematize and analyze, and handling such information is more time consuming. Lastly, assessment procedures that have been part of the educational paradigm for decades are difficult to change.

Components of Effective Authentic Assessment

The following is a list of the criteria suggested
by authors of current literature for determining the proficiency of assessment strategies and establishing the nature of assessment which is "authentic."

1. It is based on current theories of cognition and learning (Herman, 1992).
2. It is grounded in thoughts of what skills and capacities the students will need for future success (Herman, 1992).
3. Its results should provide focused information about achievements in relation to objectives (Wiggins, 1989).
4. The results should provide a foundation for decisions regarding subsequent learning needs (Wiggins, 1989).
5. Assessments should be calibrated and moderated to enable the comparison across classes and schools (Wiggins, 1989).
6. It should match the ideal curriculum in both what is taught and how it is experienced (California Mathematics Council, 1989).
7. It focuses on what students know and can do, rather than their deficiencies (CMC, 1989).
8. Its purpose should be to improve learning (CMC, 1989).
9. It espouses the notion that knowledge is constructed within the learner (Wiggins, 1989).
10. It evaluates the student's performance within a real-life context (Meyer, 1992).

Assessment has long been considered exclusively as the teachers' judgments of the success of failure of their students. There is reason to believe that it is as children participate in the assessment process, that they recognize their own capabilities and autonomy (Anderson, 1993). When assessment reflects what is actually comprehended by the student, in a way that is consistent with his/her individuality, the student is empowered and retains responsibility for what he learns.

Current Assessment Efforts

England

Great Britain has been innovative in recent approaches to assessment. In response to the direction of change that was outlined by the Cockroft Commission (Committee of Inquiry into the Teaching of Mathematics in Schools, 1982), the Assessment of Performance Unit (APU) was appointed to prepare a national profile on the educational achievement of children (Romberg et al., 1990). The APU was to encourage the inclusion, among other things, of the integration of subject areas, practical activities, language emphasis, a diagnostic approach to testing, a graduated assessment,
and records of progress (Romberg et al., 1990).

The APU utilized methods for assessment that combined pencil-paper answers to complex and real-life situations and a diagnostic assessment interview including manipulatives. The overall intent was to assess the construction of knowledge within the learner and the process that is involved, rather than measure the student's coverage of the field of mathematics (Romberg et al., 1990).

The Thatcher government enacted one of the most substantial pieces of English educational legislation, the 1988 Educational Reform Act. Among other things, the act mandated the establishment of a National Curriculum and a corresponding assessment system for all students in Grades 2, 6, 9, and 11 (Nuttall, 1992).

Designed by a panel of educationists, evaluation was a blend of the teacher's assessment of each student's progress, measured against national standards defined in the National Curriculum; and the child's performance in a succession of Standard Assessment Tasks. These tasks were administered centrally, but graded by the child's teacher. The activities consisted of ones that were so much like every-day classroom activities that the children were unaware that they were being assessed. Teachers were permitted
to administer the tasks as they wished, as no standardized instructions were prescribed (Nuttall, 1992).

This assessment proved to be popular with the children, but teachers found them to be demanding of their time and energies, and difficult to administer to the entire class.

Eventually, complaints and concerns reached the ears of Prime Minister John Major, who decided that performance components must be diminished, and plans for national assessment have been radically altered. Tasks were redesigned to be easier to administer to an entire class, and the creation of new pencil-paper tests was called for (Nuttall, 1992).

According to Nuttall, the lesson to be learned from England’s case is perhaps best summarized in the following manner: performance assessment requires the will and proficiency of education professionals, as well as the support and trust of the parents and politicians who are willing to bear the cost (Nuttall, 1992).

**United States**

Great Britain is not alone in the quest for assessments whose evaluations more closely reflect student achievement. While there are many efforts
throughout the United States, this inquiry will be limited to those in Vermont, Kentucky, Colorado, and California.

Vermont

The Vermont Assessment Program rejected skill-based assessment and implemented matrix sampling through the use of portfolios. These portfolios were both moderated and scored locally. It was noted, however, that some of the portfolios contained entries such as drill sheets, that were unscorable (Kahl, 1992).

Kentucky

In Kentucky, performance assessment and portfolios were extensively executed. Like Vermont, these were scored and moderated on the local level. Although these assessments included whole-class testing, the students were involved in various tasks during the test. In addition to the internally controlled assessments mentioned above, the schools continued to administer on-demand transitional testing, as well as performance testing (Romberg et al., 1990).

Colorado

After establishing five new district outcomes, the Aurora Public Schools in Colorado found that assessment became problematic. They sought assistance from the
Mid-Continent Regional Educational Laboratory (McREL), which developed an assessment framework that provided an acceptable model. Their "outcomes rubric" listed the following qualities to be cultivated in their students: self direction, collaborative ability, complex thinking, producer of quality products, and community contribution. These outcomes were intended to become the curriculum, the focus of instruction, and eventually their graduation requirements (Redding, 1992).

California

The California Assessment Program is in the process of revising its assessment approaches to reflect current curricular changes in California. The emphasis will be shifted to mathematical comprehension, problem solving, hands-on learning experiences, collaborative efforts, and exposure to various strands of mathematics. These revisions will be implemented gradually, and will include open-ended problems, student portfolios, enhanced multiple-choice questions, and investigations (Pandey, 1991). It is intended that as the emphasis on these new strategies increases, the use of multiple-choice questions will decrease. In addition, each year the number of participating schools will be increased to attain full participation in three
to five years (Pandey, 1991).

Conclusions

In spite of these worthy efforts toward the implementation of assessment strategies that are more authentic, changes in this area continue to be problematic and frustrated. This is due, in part, to the difficulty in establishing criteria for evaluation when there has not been concurrence with regard to the fundamental nature of such assessment (Wolf, LeMahier, & Eresh, 1992), nor in the form in which these assessments will be embodied.

According to Haney and Madaus (1989), one must refuse to yield to any single embodiment, no matter how useful it is in a specific situation. This promotes a conscious selection of assessments to match specific objectives.

Inadequate Preparation

On a more positive note, the next three items on the list; management and control problems, lack of class and preparation time are potentially more easily dealt with, and concern will be significantly diminished as the next item, inadequate preparation, is confronted.

Few, if any teachers who have been in the classroom since the early seventies were exposed to
teaching strategies involving manipulative materials. They have no first-hand experience with that style of teaching unless an effort has been made to attain these skills through extended education, in-service training, or professional workshops (Kutz, 1977). One study indicated that there is a tendency for teachers with more recent training in the use of manipulatives to use these materials more often in their classrooms (Scott, 1983).

Surveys done in the spring of 1981, and repeated in 1986 indicated that after the investment in math materials and administration of related in-service activities, there was a dramatic increase in the use of concrete materials in addition to textbooks in teaching of elementary mathematics (Scott, 1987). Other studies indicated that after attending in-service activities, teachers became competent in using manipulatives and used them regularly in their classrooms (Jagielski, 1991; Yeatts, 1989; Zilliox, 1991). It was also noted that through increased involvement in the use of math manipulatives, primary grade teachers displayed a renewed excitement for teaching mathematics. This excitement, in turn was transferred to the students. As teachers became more comfortable and confident in using numerous concrete materials, the students'
interest and motivation also increased (Yeatts, 1989).

There is some evidence that indicates a correlation between pupil attitude and intelligence and achievement (Karp, 1991; Suydam & Riedesel, 1972). Furthermore, as motivation and interest of the students increases, the degree of self-control also rises, and the transitional problems related to classroom management begin to diminish (Post, 1980). It can be further presumed that as the comfort level of the teacher rises, instruction using manipulatives will be more easily prepared for and implemented in class (Yeatts, 1989).

The Role of Teachers

It appears as though the remaining issue, stated as the difficulty for teachers to implement manipulative methods, is perhaps more accurately portrayed as the reluctance to alter the role of the teacher which is incumbent with systematic use of manipulative materials. According to Silberman (1979), if the child is to be freed in order to best utilize these experiences, the teacher must be freed first. Not knowing how to handle the fear and challenge resulting from the removal of obligatory constraints in instructional methodology, resistance emerges where control can best be maintained, in the classroom. It appears that teachers have come to "love our chains"
Assuming this to be the case, before widespread acceptance and implementation of manipulative methods for math instruction is to be expected, attention must be given to the elements of change theory that result in successful attainment of desired change.

The Change Process

It is important to consider the five steps in the change process as they apply to the implementation of systematic use of manipulatives for mathematics instruction (Alfonso, 1981).

The first step in the process of effective change is that of awareness. This is simply becoming informed about the reality of the desired change. In the instructional scenario, this step is accomplished through research and journal articles, but most effectively through the interaction between colleagues on an informal basis, i.e. the faculty lounge, grade-level meetings, and so on.

After the awareness about the proposed change is achieved, the second step, that of interest, comes into play. In this phase the person seeks more information and gives careful consideration to the suggested change. This is partially accomplished in the same manner as the awareness stage, but the addition of
organized workshops and/or seminars can provide focused information for individual examination.

At this juncture, the individual contemplating change moves into the process of evaluation, where the worthiness and functionality of the change are judged. Here the classroom teacher will apply the body of information received thus far to what he/she has experienced to be true, and draw a conclusion regarding the merit of the recommended change, hopefully moving into the next step in the change process—trial.

If the teacher has internalized the data and it is found to be congruent with personal experience and logical reasoning, the next action undertaken is that of testing the procedure to see if the theory is applicable to reality. If the trial is deemed successful, motion in the direction of the final step is made.

When the innovation has proved to be viable, the definitive action is taken and the change is accepted for systematic use. The decision is a personal one that each individual must construct for him/herself. It is only when this stage is reached that efforts to increase the use of manipulatives can be successful. Once acceptance of the benefits of change has occurred, it is feasible to address the element of discomfort
felt by many teachers when changes in their role are indicated.

Educators are accustomed to being the dispensers of knowledge to their students, and perhaps have enjoyed the picture of being considered the source from which all information flows (National Research Council, 1989). It has become evident that teachers who are involved with active learning of mathematics via concrete objects, experience a change in emphasis from one of dispenser to that of facilitator (Post, 1980). They become those who guide the child's interaction with the environment, and create situations where concepts can be discovered as the child is ready (Silberman, 1980; Copeland, 1984). The teacher's task is not a simple one, as it includes the provision of an atmosphere that is conducive to experiences which are sufficiently challenging for children, but not so difficult that they cannot succeed. In addition, there must be the appropriate blend of the familiar and the uncommon, all at the appropriate stage of learning that the child has achieved (Silberman, 1980).

It would appear that the revised role of the teacher is more complex and more demanding. However, viewing from another point of reference will present a different perspective (Post, 1980). It is one that
allows for the individualization of student assignments, releasing the teacher from traditional confines, allowing him/her to interact with both groups and individuals to address questions, and facilitates the utilization of peer collaboration, promoting basic conceptual development, all objectives that are espoused as advantageous for student intellectual growth (Post, 1980).

Summary

Researchers are continuing to add to the large body of data that deals with the use of manipulatives in mathematical instruction. Research has shown that benefits are to be gained by the systematic use of manipulatives elementary classrooms. Data has also shown that the use of manipulative strategies is consistent with accepted learning theories.

While the benefits of manipulative instruction are widely accepted, research indicates that many teachers are reluctant to change from textbook-based instruction to the discovery learning of manipulative mathematics.
GOALS AND OBJECTIVES

The purpose of this endeavor is to increase the use of manipulative materials in mathematics instruction in the elementary school. This will be accomplished by designing a curriculum guide for the in-service instruction of teachers which will make an attempt to:

1) confront the stated issues which influence teacher reluctance by suggesting possible solutions;
2) provide essential exposure to and experience with manipulative instructional strategies and;
3) provide a questionnaire for the assessment of the workshop content, format, and perceived impact on teacher/student changes.

Although much research has been conducted in these areas, this project attempts to provide a synthesis of this information and produce a cohesive body of material through which a course of action can be deduced and executed.
PROCEDURES

The project consisted of the development of a curriculum handbook for teacher inservice workshops and a field test of the handbook’s described inservice. The handbook consists of the following items:

1) needs-assessment survey to incorporate the input of the teachers from varied sites in order to custom design the workshop to those needs;

2) teacher-attitude survey to be given before the inservice seminar for comparison with post-seminar attitudes;

3) math manipulative frequency of use teacher questionnaire;

4) explanation of why manipulative teaching treatments are effective, and perhaps superior to symbolic methods;

5) guidelines for implementing the use of manipulative math activities that will set the "tone" of the classroom and assist in controlling activity noise levels;

6) suggestions for including "free exploration" opportunities to decrease the tendency for the children to play with the objects instead of participating in teacher-guided discovery activities;

7) recommended methods for obtaining inexpensive
manipulative materials that are readily accessible;
8) suggestions for alternative modes of mathematics 
assessment that would reduce or eliminate the necessity 
of using written skill-oriented tests;
9) outline of additional content material to enhance 
teacher skills in pertinent mathematics areas;
10) suggestions for a follow-up to inservice workshops 
that would allow concerns and questions to be answered 
on an on-going basis; and
11) an evaluative questionnaire on workshop format and 
content, as well as perceived attitudinal changes.

The final phase of the project surveyed the pilot 
teachers’ opinions with regard to these aspects of the 
inservice seminar presented:
1) demonstrated changes in teacher attitudes;
2) perceived/observed impact of inservice training on 
children in these teachers’ classes;
3) input on the format of the inservice seminar and 
4) evaluation of seminar content.

This knowledge, in turn, was scrutinized in an 
effort to improve future seminars of this nature.
Pre-Workshop Surveys

Needs Assessment Survey

The first procedure of this project was to prepare an assessment of the needs that are specific to the site of the workshop. According to Edelfelt (1977), involving the prospective participants in the decision-making process, through tasks such as needs assessment questionnaires, enhances the likelihood that the contents of that workshop will be implemented in the classroom. In addition, Lawrence (1974) proposes that inservice programs that have the best probability of being considered "effective" are those that involve the participants in the planning process. It is further suggested that the needs assessment is not an end unto itself, but merely the means for collecting data from which to develop meaningful program content. (Luke, 1980).

Survey of Teacher Attitudes

This project's second section provides for the administration of pre- and post-seminar surveys of teacher attitudes. According to Daane and Post (1987), teacher's attitudes toward mathematics as well as their attitudes toward their ability teaching mathematics, are viewed as being chief determiners or students' attitudes and performance in math. Feelings of dislike
of mathematics on the part of the teacher are certain
to be transmitted to the students (Widmer and Chavez,
1982). In their study, Daane and Post (1987) indicated
that as teachers' attitudes toward mathematics became
more positive, the Basic Competency Test scores of
their students increased. Furthermore, perceived
discipline/control problems showed a negative
correlation.

Lawrence (1974) studied the profiles of ninety-
seven investigations and reported a remarkable success
rate for the inservice education programs studied.
This estimation of "success" was founded on the
evidence of significant changes in teacher behavior,
believed to be the result of adjustments in teachers' attitudes affected by the inservice programs. The assertion that inservice programs have the potential to impact teacher attitudes is the basis for developing a survey (see Appendix A) in this project to appraise resultant changes.

In addition, a similar survey for administrator participation is also found in this section.

Frequency of Use Questionnaire

This questionnaire (see Appendix A) is included for utilization to solicit information with regard to the inservice participants' actual use of manipulative
materials in the classrooms. Its data is integrated with the results of the needs assessment to assist in the design of the subject matter content of the workshop.

**Curriculum Handbook**

The curriculum handbook (see Appendix B) includes the following information:
1) explanation of why manipulative teaching treatments are effective, and perhaps superior to symbolic methods;
2) recommended methods for obtaining inexpensive manipulative materials that are readily accessible;
3) guidelines for implementing the use of manipulative math activities that will set the "tone" of the classroom and assist in controlling activity noise levels;
4) suggestions for including "free exploration" opportunities to decrease the tendency for the children to play with the objects instead of participating in teacher-guided discovery activities;
5) suggestions for alternative modes of mathematics assessment that would reduce or eliminate the necessity of using written skill-oriented tests;
6) outline of additional content material to enhance teacher skills in pertinent mathematics areas; and
7) suggestions for a follow-up to inservice workshops that would allow concerns and questions to be answered on an on-going basis.

**Post-Workshop Questionnaires**

The final phase of the project developed surveys of the teachers' opinions (See Appendix C) with regard to these aspects of the presented inservice workshop:

1) demonstrated changes in teacher attitudes;
2) perceived/observed impact of inservice training on children in teachers' classes;
3) input on the format of the inservice seminar and;
4) evaluation of seminar content.

**Field Test of Handbook**

This project included a field test of the elements, which was conducted during July, 1993, at Mount Vernon School in San Bernardino, California. The twenty-four participants of this study were teachers of kindergarten through grade five. The needs assessment, teacher attitude survey, and frequency of use questionnaire were completed approximately three weeks prior to the actual workshop sessions.

The staff was divided into two groups for the sessions: grades K through 2, and grade 3 through 5. There were fifteen primary teachers, ten intermediate
teachers and two administrators participating. The
sessions were conducted on two consecutive Wednesdays
from 3:45 to 4:45 for the primary teachers, and on
Thursday for the intermediate teachers. (The
intermediate teachers were limited due to schedule
constraints.)

Follow-up questionnaires were administered at the
conclusion of the workshop, so that short-term benefits
could be assessed. The data acquired from the surveys
was tabulated, evaluated, and provided essential
information that was used to improve future workshops
of this nature.

RESULTS

The workshop was attended by fifteen staff members
on Wednesdays and ten on Thursday, for a total of
twenty-five attendees. Since one administrator
attended both sessions, the number of staff persons
involved appears to be twenty-four. Eleven of the
survey packets were completed and returned by the
teachers, one by the administrators, and one survey was
only partially completed.

The responses to the teacher attitude survey given
before the workshop indicated that most of the teachers
believed that the use of manipulatives could help build
a strong mathematical foundation for children in all
elementary grades. It was further reported that manipulatives were used both for introducing and reinforcing concepts and were available for the children to use when completing assignments. The primary teachers submitted that they used manipulatives approximately two to five days a week, totalling four to six hours. The teachers of grades three through five indicated that, although their hours of manipulative use also totalled four to six hours, they used them from zero to three days a week.

According to the needs assessments survey, priority coverage was needed in the following areas: whole class management of manipulatives, finding a balance between manipulative and textbook presentations, and alternative assessment methods. In addition, it was indicated that input was desired in the following skill areas: number concepts, fractions, multiplication, and long division.

To accommodate the targeted areas in the needs assessment survey, the workshop was designed so that the skill areas would be addressed by embedding particular activities within the general format of whole-class management strategies.

The findings that related to the reasons for reluctance to use manipulatives mentioned in the search
of related literature of this project were of further interest. None of the teachers felt concern about the children's tendency to play and/or lose the objects. Most of the responding teachers indicated that outside pressures, the expense of the materials, and not enough class time were not areas of concern for them. However, the lack of planning time was one area of concern by almost two-thirds of the teachers. Although most of the teachers indicated that assessment of manipulative mathematics activities was not problematic, more than three-fourths of them said that if they had alternative assessment procedures (other than pencil-paper tests), they would use manipulatives more often. Approximately half of the teachers felt that their preparation to teach mathematics with manipulatives was inadequate.

The post-workshop questionnaires were administered at the conclusion of the final session for both groups. Of the twenty-four participants, twenty of them returned their questionnaires.

Approximately twenty-eight percent of the teachers indicated that they now use manipulatives more frequently than before the seminar. The teachers further indicated that one third of them were using manipulatives to teach more lessons/concepts than
before the seminar. In addition, two thirds of the teachers reported that their class seems more interested in math because of new strategies that were tried. Twenty-two percent of the respondents felt that they were better prepared to use math manipulatives in the classroom.

With reference to the workshop content, twenty-two percent of the teachers indicated that their input into the needs assessment survey was reflected in the content. Furthermore, twenty-one percent indicated that the content was relevant to their classroom needs and one fourth felt the activities were realistic and beneficial for classroom use.
CONCLUSIONS

It appears that this inservice workshop made an impact on the participants as exhibited by the increase in use and frequency by some of the teachers. Even though these increases are evidenced, few of the teachers reported to feel more adequately prepared. Also in spite of the indications of change, only a small portion of the participants indicated that they felt satisfied that the workshop addressed their needs.

It appears that the information supplied by the needs assessment survey did not accurately portray the actual needs of the teachers. This could be due to incongruity between responses and actual needs, or faulty interpretation of the written responses.

It can be concluded that the needs assessment survey requires further scrutiny and evaluation to assure that future difficulties with discrepant responses are alleviated.
IMPLICATIONS FOR EDUCATION

The primary goals of this project were to verify, through teachers' self-reporting and a search of the literature, the inadequate level of implementation of manipulative mathematics instruction in elementary school classrooms, ascertain the reasons for this shortcoming, and develop a means for addressing the areas of teacher reluctance.

Research suggests that teachers continue to resist the systematic use of concrete objects in mathematics instruction for a variety of reasons. Research also provides a variety of suggestions for confronting the reasons motivating this resistance.

First and foremost, teachers must recognize that the use of concrete objects assists children in learning mathematical concepts. Evidence for this notion can be procured from many sources of literature, but total acceptance lies solely within the realm of the individual teachers.

Once the benefit of manipulative mathematics instruction is internalized by the teachers, the outside pressures are more easily encountered and silenced. Teachers who are passionate about providing the most effectual learning experiences for their students can find a way to satisfy demands to cover
textbook content and avoiding "wasting time on frills", primarily by substituting manipulative activities for the rote-based lessons.

The problem of inadequate financial resources will remain a legitimate concern for educators. While the provision of purchased manipulatives will not be forthcoming on a grand scale, teachers can focus on one or two basic manipulative purchases. These can be supplemented with handmade or "found" materials. It is not necessary to amass a large inventory of objects in order to teach meaningful manipulative mathematics.

There exists a large number of published teacher-resource books that provide assistance in strategic implementation of manipulative mathematics. One such book has been written by this writer, and is scheduled for publication by Creative Teaching Press in Cypress, California in December of 1993. The use of this publication and others like it requires resolve on the part of the teacher to independently seek out this additional information. Teacher inservice workshops also can provide teachers with knowledge of this type.

The remaining area of reported resistance: difficulty in assessing such activities is also convincingly encountered through the inservice instruction of teachers.
LIMITATIONS

The reliability of this evaluation is limited to the specific site of administration, although there may be some possibility for generalization. The available sample of participants consisted of those who took part in this program, and subsequently returned the questionnaire. Therefore, the responses cannot be considered to be taken at random, but one could consider the possibility for limited generalizability. The scope of this evaluation is also limited in its validity due to its single-site administration because of time constraints. The extent of the impact of these factors is unknown.
Pre-Workshop Surveys

Appendix A
Sample Cover Letter

Dear Teachers,

I am in need of input from in-field professionals who will take a few minutes and complete the attached questionnaire. I am compiling information with regard to the use of manipulatives in teaching math concepts in conjunction with a Master of Arts in Elementary Education at Cal-State San Bernardino. Your name is not required, but may be included if you desire.

Time is of the essence for your response, so please take a few minutes to indicate your responses and return it to the office so your input can be incorporated into my thesis documentation.

My thanks to you for assisting my attempts to provide insight into curricular issues, particularly pertaining to the instruction of elementary mathematics.

Sincerely,

Virginia M. Johnson
NEEDS ASSESSMENT FOR __________________ SCHOOL
Grade taught________________
To enable me to design an inservice that will meet the specific needs of your school, please indicate your priority of needs by placing "1" by the most important, "2" by the second, and so on.

_____Classroom management/control
_____Whole-class use of manipulatives
_____Balancing manipulatives and textbook use
_____Assessment strategies
_____How to use manipulatives to teach: number concepts
_____How to use manipulatives to teach: addition
_____How to use manipulatives to teach: subtraction
_____How to use manipulatives to teach: multiplication
_____How to use manipulatives to teach: division
_____How to use manipulatives to teach: place value
_____How to use manipulatives to teach: fractions
_____How to use manipulatives to teach: decimals
_____How to use manipulatives to teach: __________________
_____How to use manipulatives to teach: __________________
_____How to use manipulatives to teach: __________________
_____How to use manipulators in math
_____How to do problem solving with manipulatives
_____How to store manipulatives for easy access
_____How to_________________________
TEACHER QUESTIONNAIRE  Grade taught

Please indicate your choice by checking the column that best represents your opinion of that question.

4 - Strongly agree  2 - Disagree
3 - Agree          1 - Strongly disagree

1. The math textbook is my main teaching aid. 4 3 2 1
2. I use math manipulatives when teaching new concepts. 4 3 2 1
3. I use math manipulatives only when reinforcing concepts. 4 3 2 1
4. My students use manipulatives when completing their assignments. 4 3 2 1
5. Math manipulatives are not needed above kindergarten and first grades. 4 3 2 1
6. Manipulatives act only as a crutch and can do more harm than good. 4 3 2 1
7. I believe the use of manipulatives can assist in building a strong basic math foundation. 4 3 2 1
8. I would like to have more math manipulatives for use in my classroom. 4 3 2 1
9. I have attended workshops on using math manipulatives. 4 3 2 1
10. I would be interested in attending future workshops concerning the use of math manipulatives in the classroom. 4 3 2 1

How much time do you devote to teaching math each week?

_____ 0 - 2 hours  _____ 4 - 6 hours
_____ 2 - 4 hours  _____ 6 or more hours

How many days per week do you use math manipulatives when teaching math?

_____ 0 days  _____ 1 day  _____ 2 days
_____ 3 days  _____ 4 days  _____ 5 days
Teacher Questionnaire - page 2

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<thead>
<tr>
<th>Question</th>
<th>4</th>
<th>3</th>
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<tr>
<td>11. The use of math manipulatives is troublesome as the students only</td>
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<td>play with the materials.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<td>12. There is not enough class time to use math manipulatives to teach</td>
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<tr>
<td>math.</td>
<td>4</td>
<td>3</td>
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<td>13. There is not enough planning time to prepare math lessons using</td>
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<td>manipulatives.</td>
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<td>14. The use of math manipulatives is troublesome as the students lose</td>
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<tr>
<td>them.</td>
<td>4</td>
<td>3</td>
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<td>15. It is difficult to manage the use of manipulatives with an entire</td>
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<tr>
<td>class.</td>
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<td>16. The noise level reached when using math manipulatives is bothersome.</td>
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<td></td>
<td>4</td>
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<td>17. Math manipulatives are usually too expensive.</td>
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<td>4</td>
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<td>18. I do not have financial resources to purchase math manipulatives.</td>
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<td>4</td>
<td>3</td>
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<td>19. It is difficult to assess skill mastery when teaching with</td>
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<td>manipulatives.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>20. If I had alternative assessment procedures (other than pencil-paper</td>
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<tr>
<td>tests), I would use manipulatives more often.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>21. I do not feel adequately prepared to use math manipulatives in the</td>
<td></td>
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<tr>
<td>classroom.</td>
<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>22. My administrator does not indicate support of the use of manipulatives</td>
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<tr>
<td>to teach math.</td>
<td>4</td>
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<td>2</td>
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<tr>
<td>23. I am held accountable for completing the pages in the textbook.</td>
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<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
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</table>
Administrator Survey

4 - strongly agree 2 - disagree
3 - agree 1 - strongly disagree

The following questions address your viewpoint of manipulatives:

1. The use of math manipulatives is troublesome as the students only play with the materials. 4 3 2 1

2. There is not enough class time to use math manipulatives to teach math. 4 3 2 1

3. There is not enough planning time to prepare math lessons using manipulatives. 4 3 2 1

4. The use of math manipulatives is troublesome as the students lose them. 4 3 2 1

5. It is difficult to manage the use of math manipulatives with an entire class. 4 3 2 1

6. The noise level reached when using math manipulatives is bothersome. 4 3 2 1

7. Math manipulatives are usually too expensive. 4 3 2 1

8. We do not have financial resources to purchase math manipulatives. 4 3 2 1

9. It is difficult to assess skill mastery when teaching with manipulatives. 4 3 2 1

10. The student's achievement scores may drop if manipulatives are used and pencil-paper skills are decreased. 4 3 2 1

11. I do not feel that most teachers are adequately prepared to use math manipulatives in the classroom. 4 3 2 1

12. My school board does not indicate support of the use of manipulatives to teach math. 4 3 2 1
Teacher Frequency of Use Questionnaire

Please rate the following manipulatives according to frequency of usage on a regular basis in your classroom:

Unifix cubes _____1 _____2 _____3+ times a week
Attribute/pattern blocks _____1 _____2 _____3+ times
Counters (purchased or not) _____1 _____2 _____3+ times
Bundleable sticks _____1 _____2 _____3+ times a week
Geoboards/rubberbands _____1 _____2 _____3+ times
Cuisennaire rods _____1 _____2 _____3+ times
Calculators _____1 _____2 _____3+ times a week
Base ten blocks _____1 _____2 _____3+ times a week

Manipulatives I KNOW I'd use if I had them:

What I didn't like about previous workshops:

What I liked about previous workshops:

Any other comments you care to make:
Appendix B

Curriculum Handbook
INTRODUCTION

This curriculum handbook was designed to assist those who are presenters of workshops and seminars that instruct teachers in the use of manipulatives in mathematics instruction. There are several assumptions on which this guide is based.

First, it is presumed that the leaders are familiar with manipulative strategies for teaching mathematics. Presentation methods of the workshops should be consistent with teaching practices which are theoretically sound and professionally accepted. These would take into account adult developmental theories and individual differences of the participants. In addition, the presentation strategies should be congruous with the nature of the training that is being attempted. For example, using lecture as the major delivery mode when presenting a workshop that is designed to train teachers in the use of concrete objects and discovery methods is incongruous. The instructional techniques that are being taught should also be used in that teaching.

Secondly, it is surmised that workshop presenters are knowledgeable of and/or have resources which provide manipulative activities for specific
mathematical skills. The outline provided in this guide serves only as a list of probable mathematical concepts that may be indicated by the needs assessments of various school sites. The individual presenter is to supply specific procedures as the distinctive needs of the school dictates.

In addition, this handbook is not intended to be considered the panacea for persistent resistances to changes in the teaching of mathematics in elementary school classrooms. It is the attempt of this educator to add to the mass of information that is generated in an endeavor to make a contribution toward the methodical use of instructional methods from which the nation's children will derive the most benefit.

Furthermore, it is meant to supplement the manipulative math inservice with information on the use of and sources for manipulative materials; ground rules and guidelines for implementing manipulatives in mathematics instruction, including free exploration; and alternatives to pencil-paper tests as a means for assessing mathematics achievement.
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How Do Manipulatives Help Children Learn?

It has been proposed that there are several types of knowledge or intelligence. Howard Gardner (1988) refers to seven types, while Jean Piaget refers to only two: physical and logico-mathematical (Piaget, 1967). According to Gardner, logical-mathematical intelligence refers to "the ability to explore patterns, categories, and relationships by handling objects or symbols, and to experiment in a controlled, orderly way.." (Gardner, 1988, p.37). Piaget's logicomathematical knowledge was defined similarly, and develops in tandem with physical knowledge.

Elementary mathematics cannot be taught by "teaching", "demonstrating, or relying on what our sensory input conveys. Logicomathematical knowledge evolves out of a child's mental functions and his interaction with the physical world through real-life events. The link between the physical world of the child and the development of logicomathematical thinking makes manipulation an integral part of mathematics instruction (Williams & Kamii, 1986).

The use of manipulatives gives the child an event that is more abstract than a real-world experience, but is still less abstract than the use of formal symbols (Williams & Kamii, 1986). For example, when portraying
the combining of two groups of objects by using
counters, the result is more abstract than actually
handling the real-life article (such as ducks), but is
more tangible than performing the action with numerals
alone. When using concrete objects, symbols (numerals)
merely record what has been discovered tangibly.

It has been suggested that the real value of using
concrete objects comes from how they are used by the
teacher in the learning of math concepts (Ross & Kurtz,
1993). In other words, the manipulatives are not
magical in themselves, but are a means to an end.

There are several things teachers can do to help
foster this type of knowledge in their students.
1. Provide access to appropriate physical materials;
2. Ask questions that involve logicomathematical
   thinking;
3. Create meaningful situations or experiences;
4. Provide opportunities for decision-making; and
5. Encourage exchanges of ideas with peers.

The use of manipulatives in the classroom promotes
the trend by educators to focus on student
understanding rather than rote procedures (Ross &
Kurtz, 1993). This, in turn, will foster greater
logical-mathematical ability, which leads to greater
student concept understanding, and so on.
Sources of Manipulative Materials

1. Letter to parents asking for "math stuff" like paper clips, old keys, washers, bottle caps, safety pins, seeds, pods, beans, shells, and so on.

2. Utilize older students by having a "work time".

3. Have your students make them as a learning center activity or free time activity. This works best with first graders and above, and depends upon the complexity of the manipulative.

4. Have a parent "work night" where parents volunteer to come and "mass produce" materials.

5. Make up "take home kits" of materials needed to produce the manipulative. Send them home for the parents who prefer to work at home.

6. Fund-raising ideas-(administrative approval is advised):
   A. Class/school bake sale
   B. Class/school garage sale during school hours. The children bring item(s) of their own (with parent permission, of course) to sell to their school mates. Proceeds are designated to go for "math stuff".
   C. Activity/donation calendar-Fill in spaces of a calendar for one month with various activities to be done by student and family. Activities could include: count light bulbs in your house and put 1 cent in a
baggie for each one; subtract the number of doors from the number of windows and put in a penny for each window that is left; put in a nickel if you forgot to make your bed; look in the bottom of the couch and put in any coins that you find; and so on. It adds up, in all economic groups. This can be lots of fun, especially when it doubles as homework for that month.

7. Communicate with fellow teachers. Often teachers have insufficient amounts of manipulatives in their classrooms which are not being used. Work a "deal" to trade, borrow, or buy them. Pool resources.

8. If using "community" (school- or district-shared) manipulatives, instead of dividing up the materials equally between the classes using them, assign the entire quantity of each manipulative to one class, so whole-class use is possible. Teachers can then swap on a temporary basis with each other to vary manipulative use.

9. Math Walk—Take your class on a walk through a park for the purpose of collecting seed pods, pebbles, and so on.

10. Check out garage sales, especially those whose sponsor is "crafty". Many arts and crafts items lend themselves to becoming manipulatives.
Ground Rules, Guidelines, and Formats

Ground Rules

Perhaps the single most important strategy that can be implemented in the classroom to ensure cooperation when using manipulatives in mathematics instruction is firmly establishing ground rules. Class involvement in developing these rules fosters even more unity of purpose. Here are some suggested rules to get you started:

1. Stay in your assigned area (desk, station, center)
2. Work on the designated task (this may be "free exploration")
3. Be sure manipulatives are returned to their containers.
4. Establish consequences for breaking the rules.

Guidelines

1. Moving through the classroom enables you to spot students who may need help staying "focused" or who need guidance.
2. Giving students a "mental objective" will help them focus. ("While you work, think about how you figured out the answer." or "Be ready to share with the class how..."
3. Using visual signals (thumbs up, thumbs down) will promote active participation.
4. Cooperative group structure is perfect for manipulative activities. The "materials person" can obtain materials for the entire group, minimizing both time and confusion.

Formats
I. Cooperative group format-
Groups can be established in these ways, among others: 1) having the children "count off"; 2) dealing numbered cards; 3) random selection by the teacher; 4) student selection; and 5) grouping according to seating proximity.

II. Grouping in dyads, or "purposeful twosomes"-
Dyads can be established in these ways, among others: 1) numbering 1, 2, 1, 2; 2) flipping a coin; 3) random selection by the teacher; 4) student selection; and 5) grouping according to seating proximity.

III. Individual format - personal expression
Each student participates on a personal level, at his/her particular work space, desk, table, and so on.

IV. Math Stations - Learning Centers - Discovery Day
Self-directed manipulative activities are provided for independent use by the students in these designs. This format is most successful when prior whole-class modeling of exercises has been completed.
Free Exploration

After the ground rules have been established and expectations and consequences have been understood, the children are given time to "experience" the manipulative materials without the constraints of a designated task. During this time, they will line them up, build with them, feel them, smell them, and maybe taste them. They will discover the sound they make when they fall. In short, they will see what happens to this material in many situations. Because they have had an opportunity to do this, their curiosity will be satisfied when they are asked to use the materials for a specific purpose. Free exploration should be repeated occasionally after other learning tasks have been begun, to allow for further and more complex discovery.

For the most part, free exploration is precisely that...free. However, it may be necessary to offer suggestions on occasion to focus a student or start thinking processes. Here are some idea starters:

Make a design, pattern, or picture.

How far will they go if placed end to end? Stacked?
Can you duplicate your partner’s design?
How does it behave if you turn the container upside down? on its side?
Alternative Assessment Activities

Assessment methods that are relevant to student learning reinforce the fundamental idea that experiential learning is the heart of mathematics and science instruction (Bergman, 1993). It stands to reason that in the assessment of student comprehension of concepts taught through experiential activities using manipulative objects, the evaluative instrument would also include such activities and concrete objects. These assessment exercises might be embodied in student products in many forms.

Portfolios

It is of foremost importance to discuss the collection and organization of student products. Perhaps the most customary representation of such a systematic arrangement is the portfolio. By definition, a portfolio is a methodical and organized accumulation of information used by the teacher and student to observe growth of the student's knowledge, skills, and attitudes in a given content area (Vavrus, 1990). The use of portfolios can help students shed the passive attitude toward school and learning (Hansen, 1992) by inviting them to invent, organize, predict, represent, visualize, and genuinely reflect on what they are learning (Hamm & Adams, 1991).
The contents of portfolios must reflect student achievement and progress on many levels, and use a variety of formats. Included in this document are some of the most common embodiments for inclusion in assessment portfolios: children's products, journals and math logs, teacher observations, teacher interviews, responses to questioning, and student self-assessments.

Children's Products

Perhaps the most meaningful mode of assessing how well criteria are being met is the examination of children's products. What children do and what they produce can demonstrate their understanding of the ideas involved. In addition, their products can indicate: growth in social and academic areas; shifts (or the need for them) in attitudes; success in meeting established criteria; and understanding which goes beyond what has been taught (Pandey, 1991).

Furthermore, according to the California Mathematics Council (1989), using student products for instruction and assessment provide these additional benefits:
- engaging students who are not enthusiastic about school;
- bringing education to life, making it memorable;
- giving students more flexible time for thoughtful work;
- permitting students to work with others; and
- encouraging creativity.

Student-generated work may take many forms. These include those suggested by the California Mathematics Council (1989) which are listed in Handout 1 on page 78.
Handout 1

STUDENT MATHEMATICAL PRODUCTS

-experiments which the children design and complete
-models constructed by the children
-reports
-journal entries
-open-ended questions
-computer demonstrations
-bulletin boards
-student debates
-investigation reports include diagrams, graphs, tables and charts
-mathematical art
-simulations
-videotapes
-student conference presentations
-student designs and inventions
-dramatic performances
-audiotapes
-student presentations and speeches
-creative writing
-data entries and logs
-records of brainstorming sessions
Math Journals and Learning Logs

Another strategy that is used to indicate student achievement and growth is the math journal or learning log. The use of journal entries for assessment is an excellent way to chart growth in students' understanding, and it also encourages reflection on the part of the student, often revealing unconscious attitudes which impact mathematical learning. These journals can be organized in a variety of ways: a spiral notebook, a section in a loose-leaf notebook, papers kept in the pockets of a folder, or a bound notebook designed for this purpose. Entries can be made frequently on a regular basis or at a planned time, such as at the conclusion of a unit or conceptual activity. It is essential that the work is dated, and is saved for review by the student and/or teacher throughout the school year.

Journal activities that can be made at the beginning of a lesson can include making a list of everything that is known by the student about the upcoming concept or making predictions about how an idea might be used. Journal entries made before a lesson grant the student access to previous knowledge on the topic and prepares him/her to connect future ideas (Carter, Ogle, & Royer, 1993).
Entries in the journal that are written at the conclusion of a lesson provide summaries of learning outcomes, solutions to the problems, or an evaluation of the success of a particular instructional strategy (Carter et al., 1993). Some suggested questions (Hamm et al., 1991) for stimulating thoughtful responses in math journals are provided in Handout 2 on page 81.

Learning logs are accumulations of illustrations, words, and diagrams that are generated by the student both formally and informally. Student entries into learning logs made during a lesson can be used to describe their process of thinking and problem solving, as well as to supply a written record of procedural understanding (Carter et al., 1993).

When determining the criteria for assessing learning log entries, teachers must ask themselves, "What is acceptable evidence of mastery of this concept?" The spectrum of student responses is then scrutinized and adopted as valid in accordance with established objectives. Entries from the learning log can be selected by the student and/or teacher, copied, and included in the portfolio.
Handout 2

SUGGESTED QUESTIONS FOR JOURNAL RESPONSES

-What was the most important thing you learned today?
-What are you having trouble with today?
-What did you find easy today?
-What did you like most about math today?
-What did you like least about math today?
-Where did you start to figure the problem out?
-What was your mind thinking when that happened?
-Name two things you would like to forget about today.
-Name two things you are proud of today.
Teacher Observations

Observation as an evaluation strategy can be useful if a clear understanding of the behavior to be assessed has been established. These performance indicators answer two basic questions: "What does the concept or process look like at various developmental levels?" and "What defines acceptable performance?" Once desired outcomes have been determined, a checklist or rating scale is developed. Observations are especially effective in assessing areas of the curriculum whose goals are long-term in scope, that is, goals such as sharing and communicating with others, developing healthy attitudes, or participating in classroom activities (Beyer, 1993).

To be effective and revealing, observations should lead the observer into making inferences about the students and be precisely focused. In addition to observing, the teacher also reflects on the performance data to monitor students' growth and to improve instruction within the classroom (Beyer, 1993). In "Assessment Alternatives in Mathematics", the California Mathematics Council (1989) suggests inquiries in observations which are presented in Handout 3 on page 83.
Handout 3 CONSIDERATIONS IN OBSERVATIONS

With reference to learning styles, do the individuals:
- consistently work alone or with others?
- try to help others? in what ways?
- succeed in asking for/getting needed help? from whom?
- become actively involved in the problem?

With reference to explanations, do the individuals:
- try to explain their organizational and mathematical ideas?
- support their arguments with evidence?
- consider seriously and use the suggestions and ideas of others?
- attempt to convince others that their own thinking is best?

With reference to verbalization, do the students:
- talk for self-clarification and to communicate to others?
- comfortably fill the role of both "talker" and "listener"?
- have the confidence to make a report to the whole class?
- capably represent a group consensus as well as their own ideas?
- synthesize and summarize their own/group’s thinking?

With reference to cooperation, does the group:
- divide the task among the members?
- agree on a plan or structure for tackling the task?
- take time to ensure that they all understand the task?
- use the time in a productive way?
- provide support for each member?
- think about recording?
- allow for development of leadership?

With reference to manipulatives, do the students:
- choose and use appropriate manipulatives?
- fairly share handling of concrete objects, especially if there is one set for the group as a whole?
- sometimes use the manipulatives only visually? (e.g. count the red faces of a cube without picking it up.)
- appear not to need the actual objects but be able to visualize within themselves?

Teacher Interviews

The utilization of interviews can assist the teacher in assessing the depth of the student's understanding, whether the student has personally integrated the ideas and has merged them with his or her own understanding. Assessment by interview may be formal with predetermined questions, or an informal part of teaching.

Student interviews may be done outside the classroom by adults other than the teacher. In this case, the use of planned questions is essential to insure correlative responses. Interviewing can also be done while students are working on a problem. The interviewer can question one student or a group of students, taking notes during the interaction or as soon afterward as possible.

The sequence of questions in an interview should begin at a basic level of understanding with which the student is comfortable, gradually becoming more specific as the teacher attempts to focus on what the student is thinking. An essential aspect of interviewing is the use of "wait time"--as thinking often takes time for consideration and reconsideration (Ca. Mathematics Council, 1989).
Questioning

The purpose of questioning in assessment is to probe and uncover students' understanding. At best, questions are open-ended and no public judgment is made regarding the answers (Bergman, 1993).

In addition to providing assessment data, questioning can concurrently be used for instructional purposes. Questions, as well as responses, can be oral, written, or displayed with actions. When asking questions for assessment purposes, it is helpful to prepare a list of possible questions beforehand, but remaining flexible may produce rich exchanges of ideas. Use sufficient "wait time" to allow for thinking. A written record of responses and dialogue provides documentation for future reflection and evaluation.

A list that may serve as a catalyst for the development of questions that are suitable to each individual's situation is presented in Handout 4 on pages 86 through 89.
Handout 4  p.1

ASKING GOOD QUESTIONS

Problem Comprehension
Can students understand, define, formulate, or explain the problem or task? Can they cope with poorly defined problems?

-What is this problem about?
-How would you interpret it?
-Would you please explain that in your own words?
-What do you know about this part?
-Do you need to define or set limits for the problem?
-Is there something that can be eliminated or that is missing?
-What assumptions do you have to make?

Approaches and Strategies
Do students have an organized approach to the problem or task? Do they use tools (manipulatives, graphs, diagrams, calculators, computers, etc.) appropriately?

-Where could you find the needed information?
-What have you tried? What steps did you take?
-What did not work?
-How did you organize the information? Do you have a record?
-Did you have a system? strategy? design?
-Have you tried tables, lists, etc?
-Would it help to draw a diagram or make a sketch?
-How would it look if you used those materials?
-How would you research that?

Relationships
Do students see relationships and recognize the central idea? Do they relate the problem to similar problems previously done?

-What is the relationship of this to that?
-What is the same? Different?
-Is there a pattern?
-Let's see if we can break it down. What would the parts be?
-What if you moved this part?
-Can you write another problem related to this one?
Handout 4  p.2

Flexibility
Can students vary the approach if one is not working? Do they persist? Do they try something else?

- Have you tried making a guess?
- Would another recording method work as well or better?
- Give me another related problem.
- Is there an easier problem?
- Is there another way to (draw, explain, say...) that?

Communication
Can students describe or depict the strategies they are using? Do they articulate their thought processes? Can they display or demonstrate the problem situation?

- Would you please reword that in simpler terms?
- Could you explain what you think you know right now?
- How would you explain this process to a younger child?
- Could you write an explanation for next year's students (or some other audience) of how to do this?

Curiosity and Hypotheses
Is there evidence of thinking ahead, checking back?

- Can you predict what will happen?
- What was your estimate or prediction?
- How do you feel about your answer?
- What do you think comes next?
- What else would you like to know?

Equality and Equity
Do all students participate to the same degree? Is the quality of participation opportunities same?

- Did you work together? In what way?
- Have you discussed this with your group? With others?
- How could you help another student without telling the answer?
- Did everybody get a fair chance to talk?
Handout 4  p.3  

Solutions 
Do students reach a result? Do they consider other steps, possibilities? 
-Is that the only possible answer? 
-How would you check the steps you have taken, or your answer? 
-Other than retracing your how can you determine if your answers are appropriate? 
-Is there anything you overlooked? 
-Is the solution reasonable, considering the context? 
-How did you know you were done? 

Examinig Results 
Can students generalize, prove their answers? Do they connect the ideas to other similar problems or to the real world? 
-What made you think that was what you should do? 
-Is there a real-life situation where this could be used? 
-Where else would this be useful? 
-What other problems does this seem to lead to? 
-Is there a general rule? 
-How were you sure your answer was right? 
-How would your method work with other problems? 
-What questions does this raise for you? 

Mathematical Learning 
Did students use or learn some mathematics from the activity? Are there indications of a comprehensive mathematics curriculum? 
-What were the mathematical ideas in this problem? 
-What was one thing you learned? 
-What are the variables in this problem? What stays constant? 
-How many kinds of mathematics were used in this investigation? 
-What is different about the math in these two situations? 
-Where would this problem fit on our mathematics chart?
Handout 4 p.4

Self-Assessment

Do students evaluate their own processing, actions, and progress?

- What do you need to do next?
- What are your strengths and weaknesses?
- What have you accomplished?
- Was your own group participation appropriate and helpful?
- What kind of problems are still difficult for you?

These pages were taken from Assessment Alternatives in Mathematics, a booklet from the California Mathematics Council and EQUALS, 1989, and is used by permission.
Student Self-Assessment

In the examination of self-assessment, it is necessary to first define a related concept: metacognition. The metacognitive process refers to individuals' knowledge with regard to their own cognitive processes and products (Kenney & Silver, 1993). There are two facets of metacognition that are specifically pertinent to this discussion: self-awareness and self-evaluation (Kenney & Silver, 1993). Self-awareness involves taking inventory of the information already in one's bank of knowledge, and becoming cognizant of attitudes and perceptions, as well. In contrast, self-evaluation entails going beyond this awareness to a level where one makes an analytical examination of knowledge, processes, and nature (Kenney & Silver, 1993). These two components work parallel to one another in the process of self-assessment.

Self-assessment can take many forms: checklists (yes-no, true-false), questionnaires, journal entries, response scales (disagree-agree), sentence starters, or open-ended questions. It is of utmost importance that students understand the performance standards before being asked to assess their achievement. Sample questions are presented in Handout 5 on page 91.
TYPICAL SELF-ASSESSMENT QUESTIONS

1. Describe the tasks you did for the group...

2. What mathematics did you learn?

3. How does this relate to what you have learned before?

4. What could you have done to make your group work better?

5. What worked well in your group?

6. What new questions did this raise?

Sentence starters for journal responses:

1. Today in mathematics I learned....

2. When I find an answer I feel....

3. My plan for what I will do tomorrow is....

4. Of the math we've done lately, I'm most confident about.....

5. What I still don't understand is......
"Assessing" the Portfolio

Creating and organizing the students' work into a portfolio is merely the first step in the process of portfolio assessment. In evaluating the contents of a student's portfolio, teachers will find themselves presented with the need to wrestle with some difficult judgment calls. How much credit should be given for effort? How is reasoning recognized in the writing of an illiterate young child who struggles with learning the language (Wolf, LeMahieu, & Eresh, 1992)?

One of the tools available and extremely functional is the rubric. Rubrics are well-defined scoring systems that are developed to evaluate specific outcomes. They are most operative when accompanied by samples of typical student work in each of the emergent classifications. For example, specimens of excellent work, strong work, satisfactory work, and less-than-satisfactory work provide a basis for evaluation. Rubrics are often referred to as performance standards, but differ in nature from the standards of the past. Operating on a continuum, rubric assessment makes allowances for all children regardless of their rate of growth. An example of performance standards for student work is submitted in Handout 6 on page 93.
<table>
<thead>
<tr>
<th>Level</th>
<th>Standard to be achieved for performance at specified level</th>
</tr>
</thead>
</table>
| 6     | Fully achieves the purpose of the task, while insightfully interpreting, extending beyond the task, or raising provocative questions.  
-Demonstrates an in-depth understanding of concepts and content.  
-Communicates effectively and clearly to various audiences, using dynamic and diverse means. |
| 5     | Accomplishes the purposes of the task.  
-Show clear understanding of concepts.  
-Communicates effectively. |
| 4     | Substantially completes purposes of the task.  
-Displays understanding of major concepts, even though some less important ideas may be missing.  
-Communicates successfully. |
| 3     | Purpose of the task not fully achieved; needs elaboration; some strategies may be ineffectual if not appropriate; assumptions about the purposes may be flawed.  
-Gaps in conceptual understanding are evident.  
-Limits communication to some important ideas; results may be incomplete or not clearly presented. |
| 2     | Important purposes of the task not achieved; work may need redirection; approach to task may lead away from its completion.  
-Presents fragmented understanding of concepts; results may be incomplete or arguments may be weak.  
-Attempts communication. |
| 1     | Purposes of the task are not accomplished.  
-Show little evidence of appropriate reasoning.  
-Does not successfully communicate relevant ideas; presents extraneous information. |

(from Pandey, 1991, p. 30)
Conclusions

The development of alternative assessment strategies will be of little or no consequence if it is not understood that they reflect and require a view of math instruction that transcends the traditional concept of algorithms and calculations. It is presumed that such a vision includes the systematic use of concrete objects that are appropriate for the students and concepts to be taught.

Research has indicated that regardless of the resourcefulness of the tasks, teachers will not utilize them for assessment purposes if:

1) they do not display their own comprehension of math;
2) they do not perceive them as measuring pertinent mathematical material; and
3) they do not see the measured outcomes as valuable (Cooney, Badger, & Wilson, 1993).

It appears that classroom teachers are functioning as change agents in the implementation of yet another innovation in educational theory and instruction. It remains to be seen whether it is possible for alternative assessment strategies to be implemented, or whether it will be assimilated as another demand on their insufficient available time.
OUTLINE OF CONTENT MATERIAL

MANIPULATIVE MATHEMATICS INSTRUCTION

I. Classroom management and control
   A. Whole-class use
   B. Small group use
   C. Learning center use
   D. Independent use
   E. Storing for easy access

II. Balancing manipulatives and textbook use

III. Using manipulatives to teach content
   A. Shapes
   B. Classifying and Sorting
   C. Patterning
   D. Number concepts
      1. Counting
         a. rote counting
         b. skip counting
      2. Odd and even numbers
      3. Equations
         a. number families
         b. inequalities
            i. greater than
            ii. less than
   E. Sequencing
   F. Calendar
G. Addition
H. Subtraction
I. Graphing
J. Estimation
K. Place Value
L. Telling Time
M. Measurement
   1. Length
   2. Weight
   3. Volume
   4. Temperature
N. Money
O. Fractions
P. Geometry
Q. Multiplication
R. Division
S. Decimals
IV. Alternative Assessment Strategies
V. Using calculators in math
VI. Problem solving with manipulatives
INSERVICE FOLLOW-UP SUGGESTIONS

It is significant to note that the inservice training that included provisions for a systematic follow-up program had a greater chance of impacting changes that were continuous (Kramer & Betz, 1987). Each of the following suggestions have disadvantages as well as benefits. The unique needs and program of each school site, as well as the preference of the administrator will be the greatest determinant of which of the following models will suit their structure best.

1. Monthly appearance at a staff meeting, upon invitation, of course, to answer questions about implementation difficulties. This would involve a varying amount of time according to the number of questions to be addressed. It could also add confusion to a busy time, if not organized effectively, and with the support of the administrator.

2. Weekly newsletter with questions supplied by teachers and answers that you provide, using teacher suggestions. An on-going dialogue between the staff and inservice provider. This would involve time to pick up and deliver issues to preserve timeliness. It would
foster feelings of individual attention to difficulties, as well as value in sharing experiences and validity of input. Hopefully, this could extend into improved communication and sharing on the part of the staff when presenter involvement ceases.

3. Weekly/monthly questionnaire to keep manipulative math in the forefront of their thinking, and spark additional lesson ideas. This would provide an ongoing dialogue of a less demanding nature than the aforementioned newsletter, but could meet the same objectives.

4. Schedule an additional inservice workshop to address new needs of the staff. With budgetary constraints, this might prove to be unlikely. However, the motivation produced by a familiar and (presumably) respected presenter could create greater possibility of continued implementation of manipulatives by the teachers.
HANDBOOK REFERENCES


Ross, R. & Kurtz, F. (1993). Making manipulatives work:


ADDITIONAL RESOURCES

Assessment in the mathematics classroom 1993 NCTM Yearbook. Reston, VA: National Council of 
Teachers of Mathematics.


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VA National Council for Teachers of Mathematics.

703-713.
Appendix C

Post-Workshop Questionnaires
Post-workshop Questionnaires

It has been suggested that the inclusion of opportunities for feedback from workshop participants increases the probability that the proposed changes will be implemented (Lawrence, 1974, Edelfelt, 1977). This feedback is embodied in an evaluative questionnaire, which is completed immediately following the program, to evaluate short-term gains; and again after a period of time has lapsed, to determine sustained, long-term benefits.

Also included in this section are: administrator attitude survey, workshop format evaluation, and workshop content evaluation.
FOLLOW-UP QUESTIONNAIRE (TEACHERS)

Grade__________

Please give your responses to the following statements with regard to the workshop on manipulative math:

4 - Strongly agree 2 - Disagree
3 - Agree 1 - Strongly disagree

1. Math manipulatives are beneficial to children in all elementary grades. 4 3 2 1
2. My class seems more interested in math because of new strategies tried. 4 3 2 1
3. I believe the use of manipulatives can assist in building a strong basic math foundation. 4 3 2 1
4. I am now using manipulatives more frequently than before the seminar. 4 3 2 1
5. Students playing with manipulatives is not a problem. 4 3 2 1
6. There is not enough planning time to prepare manipulative math lessons. 4 3 2 1
7. I am using manipulatives to teach more lessons/concepts than before the seminar. 4 3 2 1
8. It is difficult to manage the use of math manipulatives with an entire class. 4 3 2 1
9. My students are using manipulatives independently more often in math. 4 3 2 1
10. The noise level reached when using manipulatives is bothersome. 4 3 2 1
11. It is difficult to assess skill mastery when teaching with manipulatives. 4 3 2 1
12. I feel that I can now find other ways to use the textbook pages/activities. 4 3 2 1
13. I feel better prepared to use math manipulatives in the classroom. 4 3 2 1
FOLLOW-UP SURVEY (ADMINISTRATOR)
Please give your responses to the following statements with regard to the workshop on manipulative math.

4 - Strongly agree 2 - Disagree
3 - Agree 1 - Strongly disagree

1. Math manipulatives are not needed above kindergarten and first grade. 4 3 2 1
2. Manipulatives act as a crutch and can do more harm than good. 4 3 2 1
3. I believe the use of manipulatives can assist in building a strong basic math foundation. 4 3 2 1
4. I am observing a greater frequency of manipulative use than before the seminar. 4 3 2 1
5. The use of manipulatives is troublesome because the students play with them. 4 3 2 1
6. There is not enough planning time to prepare manipulative math lessons. 4 3 2 1
7. I feel the teachers are using manipulatives to teach more lessons or concepts than before the seminar. 4 3 2 1
8. It is difficult to manage the use of math manipulatives with an entire class. 4 3 2 1
9. In general, the students are using manipulatives independently more often to assist them in math. 4 3 2 1
10. The noise level reached when using manipulatives is bothersome. 4 3 2 1
11. It is difficult to assess skill mastery when teaching with manipulatives. 4 3 2 1
12. I feel my teachers are better prepared to use math manipulatives. 4 3 2 1
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<tr>
<th>Statement</th>
<th>4</th>
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<tbody>
<tr>
<td>1. The workshop content reflected the input of the needs assessment survey.</td>
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<td>2. The workshop content was relevant to my classroom needs.</td>
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<td>3. The content of the workshop appeared to have a valid theoretical base.</td>
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<td>4. The information presented was useful and practical.</td>
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<td>5. The activities suggested were realistic and beneficial for classroom use.</td>
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<td>6. I wish we would have had time to learn:</td>
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<td>7. I have ideas about manipulative math to share in these areas:</td>
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<td>8. Other suggestions or ideas about workshop content:</td>
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9. The format of this workshop was effective (3 sessions of 1 hour) because ___________________________ 4 3 2 1

10. I prefer one 3-hour session because ________________________________ 4 3 2 1

11. Our comments/input on the needs assessment survey were considered in the seminar format and content. Please give specific examples______________________________ 4 3 2 1

12. The workshop sessions were geared to our needs and paced correctly, not too slow, not too fast. 4 3 2 1

13. I will make use of the follow-up opportunity to get questions answered because ________________________________ 4 3 2 1

14. Other comments with regard to seminar format


15. Your last chance! Anything else you would like to say:


Thank you for your assistance. Your input is indispensable and will be used to improve future inservice workshops.
PROJECT REFERENCES


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