

**A COMPARISON OF THE
CALIFORNIA PUBLIC SCHOOL AND
MONTESSORI ELEMENTARY CURRICULUMS**

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Submitted in partial satisfaction of
the requirements for the degree of

Master of Arts

School of Education
Saint Mary's College
Moraga, California

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May 1994

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INTRODUCTION

Educational reform in the state of California has emphasized aligning public school curriculum standards with current theory and research on how children learn. Modern developmental psychology, supported by cognitive research, has changed the way learning has been viewed and has prompted educators to reassess and revise traditional educational practices (*It's Elementary*, 1993). In addition to reworking existing programs, many districts have turned to non-conventional instructional models as a means for expediting curricular reform. The Montessori method is one such program that has received widespread national attention as a time-tested, comprehensive alternative to traditional educational approaches.

The Montessori System of Education

Maria Montessori, an Italian physician, educator, and social reformer, developed the Montessori system of education over a period of more than 40 years beginning in the early 1900's. Based on the holistic development of the child, the Montessori approach consists of a methodology and philosophy of education that caters to student's individual needs and their natural desire to learn. A specific educational environment is prepared to accommodate the child at each stage of development, and manipulative materials enable students to explore and discover concepts and ideas through their own activity. At the elementary level, which serves children from six to twelve years of age, key concepts and relationships are presented to motivate students to pursue their own interest, and self-development through mental activity is emphasized rather than the attainment of specific academic goals and objectives. Montessori teacher training focuses on the psychological and developmental characteristics of the child, and prepares the educator for applying principles and practices consistent with Montessori philosophy.

California's Public School Curriculum

Public education in the state of California is in a period of tremendous change. Prior to reform efforts, the state's elementary curriculum was based on a theory of learning that viewed development as the sum of discrete learnings. The acquisition of basic academic skills was emphasized, and teacher recitation, drill, and passive rote learning dominated instruction (*It's Elementary*, 1993). This approach to education, which reflects a behaviorist perspective of intellectual development, is now being replaced with a view of learning that emphasizes the child's active involvement in the building of intelligence. The state of California has undertaken to accommodate this new perspective of learning by reconceiving its curriculum standards for public education from kindergarten through grade twelve.

The revised curriculum standards established by the state are published by the California Department of Education in a series of documents called frameworks. Each year a new framework in one of seven subject areas is rewritten and updated by a committee of specialists in order to influence program development and implementation from kindergarten through the twelfth grade. The frameworks provide direction to publishers for the development of textbooks and instructional materials, and establish guidelines for helping districts to evaluate and revise their programs. Collectively, the frameworks outline a new direction for public education in the state that emphasizes a thinking, student-centered curriculum rather than the skill-based approach that has long dominated traditional education.

Statement of Purpose

This paper examines the Montessori elementary curriculum from a theoretical perspective, investigates research pertaining to Montessori education, and describes and

compares the state and Montessori elementary curriculums in four subject areas. These areas include: (a) history-social science, (b) science, (c) mathematics, and (d) English-language arts. It is the intent of this paper to establish the Montessori model of education as a viable alternative to traditional education in the state of California, and to highlight educational practices in the Montessori system that facilitate the implementation of a developmentally oriented curriculum.

Comparison Format

In each academic area considered, both the state and Montessori curriculums are described and then compared according to similarities and differences in content, organization, and instruction. The state curriculum descriptions summarize the information contained in the four most recently published frameworks in the areas of history-social science (1988), science (1990), mathematics (1992), and English-language arts (1987). The Montessori curriculum descriptions have been derived from a variety of sources including books and articles written by Dr. Montessori and others, and from lecture notes obtained from Montessori training at both the early childhood and elementary levels. Each curriculum summation includes a rationale for the instructional program used with both the preschool and elementary child, and discusses the lessons and materials presented at each level of the curriculum.

A THEORETICAL ANALYSIS OF THE MONTESSORI ELEMENTARY CURRICULUM

The Montessori method of education is based on a comprehensive theory of development derived through Dr. Montessori's careful observation of the child. This view of development is consistent with current theory and research on how children learn, and is in line with the educational reform objectives recently established by the state of California. This chapter will examine the Montessori elementary curriculum from a theoretical perspective and demonstrate that the Montessori method has much in common with contemporary developmental theory as well as agreement with some behaviorist applications of intellectual growth.

Cognitive-Developmental Perspective

Cognitive theorists, such as Piaget, view development as the result of changes in the child's cognitive structures. These changes occur gradually as the child constructs her own knowledge by interacting with her environment and the people in it in an intellectually stimulating manner. While these changes are cumulative, they also proceed through successive developmental stages, which provide possibilities for new ways of thinking and learning. Each stage incorporates developmentally earlier structures in a higher synthesis and is characterized by a relatively stable general structure (Furth, 1970). The child's meaningful physical and mental interactions within the environment help her to transition from one stage to the next and are necessary for learning and cognitive development to occur.

Cognitive theorists view development as the primary aim of education (DeVries & Kohlberg, 1987), and recommend providing students with numerous opportunities to act

on their environment in intellectually relevant ways. Allowing students to manipulate concrete objects and to choose developmentally appropriate experiences is seen as essential for cognitive growth and learning to occur at the elementary level and must be incorporated in the structure of educational programs. The importance of allowing children to initiate their own activities for intellectual development has been summarized by Piaget (1970) in the following statement:

When the active school requires that the student's efforts should come from the student himself instead of being imposed, and that his intelligence should undertake authentic work instead of accepting pre-digested knowledge from the outside, it is therefore simply asking that the laws of all intelligence should be respected. (p. 159)

Self-chosen endeavors often reflect the spontaneous interests of the child and frequently indicate that cognitive conflict, which is necessary for mental growth, has been generated (Wadsworth, 1989). The child's interests motivate her to act on the environment in a constructive manner and must be aroused for effective learning to take place. Jerome Bruner emphasized the importance of stimulating the child's interest in his theory of education and states in *The Process of Education* "motives for learning must be kept from going passive in an age of spectatorship, they must be based as much as possible upon the arousal of interest in what there is to be learned" (Bruner, 1978, p. 80).

Montessori also believed that children construct their own intellects by acting on the environment according to their spontaneous interests and structured her elementary curriculum accordingly. Rather than designing a content specific program of study where learning is achieved through coverage, Montessori established a framework for systematically acquiring knowledge and emphasized the child's self-development through mental activity rather than specific academic goals and objectives. The elementary curriculum is structured around self-initiated activities and research projects based on key presentations, and the child's active involvement is viewed as crucial to the learning

process. Concrete materials enable students to construct conceptual understanding in every subject area of the curriculum and help children to discover concepts and procedures on their own. Montessori acknowledged the child's role in building her own intellect throughout her writings and relates the concept of self-construction to her method of education in the following passage:

The older child, who seems so troublesome being curious over the what, why and wherefore of everything he sees, is building up his mind by this mental activity, and must be given a wide field of culture on which to feed. The task of teaching becomes easy, since we do not choose what we shall teach, but should place all before him for satisfaction of his mental appetite. (Montessori, 1973, p. 7)

Montessori recognized the significance of arousing the child's interest in learning and devised techniques for igniting both curiosity and enthusiasm. She states that the role of education is to "interest the child profoundly in an external activity to which he will give all his potential" (Montessori, 1976, p. 24), and emphasized the importance of stimulating the child's interest by stating:

How can the mind of a growing individual be interested if all our teaching be around one particular subject of limited scope, and is confined to the transmission of such small details of knowledge as he is able to memorize? How can we force the child to be interested when interest can only arise from within? (Montessori, 1973, p. 9)

Montessori's emphasis on generating interest to learn from within the child reflects a cognitive perspective of intellectual development as does her belief that knowledge is acquired through the child's own efforts. By providing appropriate materials and enabling students to pursue their own interests, rather than imposing knowledge verbally or by assigning specific activities, the curriculum cultivates the child's own ability to learn and is developmentally oriented.

Cognitive theorists also consider social interactions as an essential condition for cognitive growth (Bornstein & Bruner, 1989). While physical and logical-mathematical

knowledge are acquired by acting on objects, the child constructs social knowledge by acting on or interacting with other people. However, in addition to building the child's social knowledge, Piaget contends that the verbal exchanges which occur during peer interactions also benefit the child's development of moral rules and logical thought by subjecting the child to viewpoints different from her own (Lefrancois, 1982). By potentially stimulating cognitive conflict, social interaction helps the child to become aware of differing points of view and helps the child to develop objectivity in her thought. Mutually beneficial peer tutoring is one technique that can be employed within the classroom to promote social exchanges contributing to the mental growth and moral development of the child.

Vygotsky was also aware of the importance of social exchanges for cognitive growth. His theory emphasizes the significance of language in the development of higher mental functions and stresses the importance of engaging children in interactions with people who are more skilled than they (Bornstein & Bruner, 1989). Both Piaget and Vygotsky identified intersubjectivity between partners, or the active exchange of thoughts and ideas, as an essential variable for social interaction to be effective.

Montessori viewed social interactions as an essential component for fostering moral development in children. She believed that the moral teachings of life emerged through social experiences and encouraged peer interactions throughout her plan for education. Montessori also observed that "knowledge and social experiences must be acquired at one and the same time" (Montessori, 1976, p. 26), and structured her elementary curriculum with development in both areas in mind. Her method encourages social exchanges through optional group investigations and endorses the free exchange of ideas amongst students and between students and their teachers. Numerous opportunities for peer tutoring are possible through the open work environment established within the

classroom and the system's use of mixed age groupings. The curriculum's emphasis on promoting collaborative work and meaningful social interactions reflects a cognitive perspective toward intellectual development and learning.

Cognitive theorists view development as the interaction of maturation, experience, social interaction, and equilibration, which serves to coordinate these other factors and regulates development in general. Because children experience these factors differently, their rate of intellectual growth can vary considerably with any group of similarly aged children operating at many different levels of conceptual development. The educational implications of catering to the diverse range of abilities exhibited by children should be obvious--individual differences in cognitive functioning must be taken into account. Curriculum methods and materials must consider the range of cognitive levels present among any group of children in which instruction is intended and should be structured to accommodate differences accordingly.

Montessori was aware that children differ significantly in their areas of strength and their abilities and sought to foster individual competencies in her elementary curriculum by allowing children to choose their own activities and areas of research. Rather than assigning specific work to be completed, the Montessori elementary curriculum is open-ended and enables students to explore topics of concern in their own manner and at their own depth of conceptual understanding. The materials introduced in the curriculum stimulate the interests of the student and frequently may be used at many different levels of difficulty. Children are able to progress at their own rates and their individual needs and interests are accommodated.

The Montessori elementary curriculum, which is representative of Montessori's philosophy in general, demonstrates a cognitive perspective of intellectual development by emphasizing the child's actions on the environment, using of the child's interests as a

motivator for learning, encouraging social interactions, and individualizing instruction. Montessori's view that development should be the aim of education is also in agreement with a cognitive perspective of learning and intellectual growth.

Behaviorist Perspective

While many aspects of the Montessori approach to elementary education suggest a cognitive perspective of conceptual growth, a few elements within the grade school curriculum reflect a behaviorist orientation toward intellectual development. The curriculum's emphasis on individualized learning and evaluating the instruction, rather than the learner, suggests that some features of the curriculum could be viewed from a behaviorist perspective.

Behaviorists view cognitive development as the result of guided learning and teaching (Kohlberg & Mayer, 1972). Development takes place in gradual, incremental steps, which build on previous learnings, and is assumed to have occurred if the child's behavior reflects a progression toward performances characteristic of older children. The more the child learns the greater her ability to build on the knowledge she already possesses and the easier it becomes for her to engage in higher-level learning. Intellectual development is promoted in education by identifying specific learnings in each curricular area and formulating a program for introducing these in a logical, sequential manner (Taba, 1962). Content is arranged hierarchically with simpler concepts necessary for later learning introduced first and the more complex processes of thinking and problem solving reserved for later learning. To adequately provide instruction, the skill that is to be imparted must also be analyzed into a hierarchy of specific performances and external conditions must be designed to promote the learning of each component in the hierarchy (Rohwer, Ammon & Cramer, 1974). Because

children differ in the learnings they possess, instruction must be individualized to meet the needs of each child.

Montessori education in general is based on meeting the individual needs of children. One way she has succeeded in doing this is by introducing the technique of analyzing tasks into their component parts. The student is introduced to each element of a task separately and is ready to tackle the composite exercise once she has mastered the prerequisite skills required for completing the activity. This system of task-analysis, which parallels the behaviorist instructional plan of forming hierarchies of learning, has been applied in the elementary Montessori curriculum within specific materials and through the basic plan of self-initiated research projects. The curriculum's format enables the teacher to individualize the instruction she does provide according to each child's needs and interests, and allows children to choose their own learning activities corresponding to their individual levels of ability.

Another area of similarity between Montessori philosophy and behaviorist principles is the emphasis both approaches place on the importance of evaluating instruction, or the environment, rather than the learner. S-R theorists suggest using the behaviors of the student to determine whether the instruction given has been successful. If the child can demonstrate that she has attained the designated objectives through her performance, the teaching is considered to be effective. Behaviorists also recognize the possibility of evaluating the instruction at any time during the implementation stage, including before the instruction has even been given.

Montessori repeatedly stressed observing the child to determine whether the prepared environment was meeting the child's specific needs. She prepared materials with built-in controls of error to enable students to evaluate their own performances, and recommended that teachers continually observe their students in order to instruct and

prepare the environment more effectively. Montessori acknowledged the significance of teacher observation of the child by stating:

The teacher must bring not only the capacity, but the desire, to observe natural phenomena. In our system she must become a passive, much more than an active, influence, and her passivity shall be composed of anxious scientific curiosity, and of absolute respect for the phenomenon which she wishes to observe. (Montessori, 1964, p. 87).

Montessori's educational plan frequently involves the teacher in student observations and in evaluating the environment to determine its effectiveness. A child having difficulty would be demonstrating that the instruction she received was ineffective or that the materials she used were inadequate or inappropriate. The situation would be viewed as an indication that changes needed to be made in the environment or the instruction, and would not be used as a means for evaluating the child. This orientation toward evaluation and the need for individualizing the learning experience suggests that the Montessori elementary curriculum does exhibit some elements of behaviorist thought toward development.

Conclusion

Even though the Montessori elementary curriculum does incorporate certain practices that reflect a behaviorist orientation toward development, many features of the method suggest a cognitive-developmental view of thinking and learning. This perspective is in line with new curriculum standards for public education established by the state of California and supports the Montessori method as an alternative to traditional education.

RESEARCH ON MONTESSORI AS AN EDUCATIONAL ALTERNATIVE IN THE PUBLIC SECTOR

The Montessori model of education has become increasingly popular in the public sector with over 43,000 students currently enrolled in more than 180 programs operating in 80 districts nationwide (Schapiro, 1995). The number of students in public Montessori classrooms has tripled in the last ten years and programs are increasingly being used with at-risk populations of children in both urban and rural localities. Despite the rapid growth of Montessori in the public sector, research assessing the effectiveness of the method at the elementary level is almost nonexistent. The use of private school Montessori students within the few studies that are available make it difficult to attribute any gains made strictly to the method and limits the possibility of generalizing the results to public school populations. In order to support the Montessori method as a valid alternative to traditional elementary practices in public education it is necessary to consult research focused on the effects of preschool Montessori education.

An extensive body of research assessing the impact of Montessori early childhood education was created during the sixties and seventies (Boehnlein, 1988). However, many of these studies were of poor quality due to flaws in their design and misunderstandings as to what constitutes Montessori education. Researchers not well acquainted with Montessori theory and practice frequently studied improperly implemented programs in which children were not exposed to authentic Montessori education (Boehnlein, 1988; Kahn, 1990; Chattin-McNichols, 1992). The use of untrained or inexperienced teachers, the lack of mixed age groupings of children, and evaluations based on only a year or less of exposure rather than the full three year cycle severely limited the Montessori experience of many of the children tested. Regardless of

these limitations, many of the studies provide evidence that suggests that even compromised Montessori preschool education has a positive effect on the cognitive, academic, and social development of children. The results suggest that the effects of preschool Montessori experience on children's academic achievement persists into the elementary years (Miller & Dyer, 1975; Reich, 1974; Takacs & Clifford, 1988) and into secondary school (Miller & Bizzell, 1983, 1984; Karnes, 1978), and that longer exposure to the approach yields more positive results (Berger, 1969; De Jong, 1985; Flynn, 1990; Glenn, 1989; Takacs & Clifford, 1988). Research focusing on the consequences of preschool Montessori experience provides evidence of the method's effectiveness and supports the continuing expansion of Montessori education into the public sector.

It is the intent of this chapter to present: (a) an historical overview of Montessori research describing its evolution and the different types of studies completed; (b) a definition of authentic Montessori which was used as a criteria for examining the studies included; (c) a summary of the studies grouped according to the major focus of the research presented; and (d) a summary and discussion of educational implications and areas of Montessori education needing research.

Historical Overview of Montessori Research

During the 1960's, a shift away from the heredity view of intelligence stimulated renewed interest in early childhood education and the Montessori method, which had been regaining popularity in this country since the late 1950's (Berger, 1970). The government's War on Poverty made federal funds available for early childhood research, and Head Start programs were implemented to help prepare economically disadvantaged children for regular schooling (Boehnlein, 1988). Montessori classrooms were established in a number of Head Start programs and were used in comparison studies to

assess the impact of different preschool experiences on children's academic achievement and intellectual ability (Berger, 1969; Karnes, Teska & Hodgins, 1970; Miller & Dyer, 1975; Seefeldt, 1977; Toll, 1976). The differential effects of the Montessori curriculum on low socioeconomic children and middle class children were also explored (Stodolsky & Karlson, 1972) as well as the consequences of both socioeconomic status and curriculum on children's academic and intellectual growth (Guidubaldi, Bersani, Kehle & Sexton, 1974; Wexley, Guidubaldi & Kehle, 1974).

Research (Banta, 1969; Berger, 1969) suggesting that Montessori children maintained and even gained competence over time helped to generate interest in long term assessment of the method. Longitudinal and follow-up studies which compared the standardized test scores and intelligence quotients of students who had experienced different early childhood treatments were initiated (Karnes, 1978; Miller & Bizzell, 1983, 1984; Prusso, 1977; Reich, 1974) and an attempt was made to investigate the possible influence of preschool experience on later behavioral and social characteristics of children (Gross, Green & Clapp, 1970).

During the 1970's, the effect of Montessori education on social development was explored in more depth. Comparison studies primarily in private Montessori schools were initiated to study the type of social interactions (Reuter & Yunik, 1973; Murphy & Goldner, 1976) and the amount of opportunity for socialization (Berk, 1973; Baines & Snortum, 1973), which occurred in different early childhood settings. The impact of previous Montessori training on communication ability was also investigated (Gross, Green & Clapp, 1970) as well as the effect of the amount of time in a Montessori environment on children's social interactions (Flynn, 1990). How children become socialized in a Montessori classroom as opposed to a traditional setting was also explored (Villegas, 1988).

Elementary Montessori programs were first implemented in the public sector in the late sixties (Chattin-McNichols, 1983). Two to three districts began new programs each year until the late seventies when many new Montessori programs were started as magnet schools. During the eighties there was a 500% increase in the number of Montessori magnet schools (Kahn, 1990) and Montessori growth in the public sector continues to this day. Despite the need and possible opportunities for initiating research within these public elementary Montessori programs, only two studies have been completed to date. The academic performance of public elementary Montessori students by race was examined in one study (Dawson, in Chattin-McNichols, 1992) and middle school students with public Montessori elementary experience were compared to their classmates who did not experience Montessori education in the second investigation (Duax, 1988).

Other recent studies have included comparisons of private elementary Montessori students with their public school peers (De Jong, 1985; Glenn, 1989; Staskey & Chester, 1989), a follow-up of low socioeconomic children from a public Montessori preschool (Takacs & Clifford, 1988), a case study of two 3-year-old Montessori children (Villegas, 1989) as well as Villegas' (1988) ethnographic study of the socialization process of children in a Montessori early childhood classroom.

A Definition of Montessori Authenticity

The assumption that all Montessori schools are the same is a common misunderstanding. Interpretations of the method differ considerably particularly in this country where there are numerous training organizations and no legal specifications for what constitutes Montessori education. The two largest organizations, the Association Montessori Internationale (AMI) and the American Montessori Society (AMS), have

issued similar standards for their member schools, which can be used as criteria for establishing Montessori authenticity (Boehnlein, 1988). These standards will serve as a bases for authenticity in this paper and include: (a) the teacher was accredited through AMI or AMS, (b) the class consisted of mixed ages of children spanning 3 years-of-age, (c) the school day was a minimum of two and one-half to three hours for five days per week for nine months, (d) the classroom was fully equipped with Montessori and appropriate handmade materials, and (e) the classroom offered the complete Montessori curriculum within a structure of freedom of choice for extended, uninterrupted individual and small group work time. The authenticity of the Montessori programs included in the following studies varies substantially. Therefore, the results attained must be evaluated accordingly.

Montessori Research

Early Comparative Studies

Early studies comparing the effects of various preschool experiences on children's academic achievement and intellectual growth differ significantly in their assessments of the Montessori method. While Head Start Montessori children were consistently found to be superior in academic and intellectual development to similar low socioeconomic children without preschool experience (Banta, 1968; Miller & Dyer, 1975; Guidubaldi et al., 1974), there were considerable differences in how the disadvantaged Montessori children compared to Head Start children with preschool experience in other experimental programs. Many of these differences can be attributed to defective research designs, an ignorant view of what Montessori is, and the erroneous assumption that all Montessori programs are the same.

A review of these early comparative studies suggests that classrooms that adhered more closely to authentic Montessori practices exhibited more substantial gains than those programs classified as Montessori, which did not meet authentic Montessori criteria. To illustrate this point, two studies that differ in their results are compared and three other investigations are discussed in terms of how design limitations influenced the results obtained.

Berger (1969) compared the effects of Montessori early childhood education to conventional kindergarten training on the learning outcomes of inner city children and concluded that there were benefits to Montessori preschool as compared to traditional training. Ninety-three 3 and 4-year-old Head Start children were randomly assigned to four classes--two traditional and two Montessori. Certified Montessori teachers (AMI and AMS) were found for both of the Montessori classrooms and a series of classroom observations were undertaken by the research team. After one year of treatment, the children completed a battery of tests constructed by the Center for Urban Education assessing their visual-perceptual and cognitive abilities. The *Cincinnati Autonomy Test Battery (CATB)* was also administered to assess cognitive style dimensions. On the perceptual-conceptual battery, results significantly favored the Montessori children in two of the three assessment areas--cognitive style patterning and visual-perceptual functioning. Montessori children were also favored on the *CATB* where they consistently scored higher on measures of motor impulse control, field independence, and task persistence. Observational records indicated that the examiners rated the Montessori children as being more socially competent than the traditional children and as needing less extrinsic reinforcements of praise or reassurance. Identical test results favoring the Montessori children were obtained on each of the batteries a year later (Berger, 1970)

In contrast, Karnes, Teska and Hodgins (1970) assessed the differential effects of four preschool programs, including Montessori, on the intellectual and language development of 4-year-old disadvantaged children and the results obtained did not favor the Montessori method. Sixty disadvantaged children were assigned to a traditional nursery school program (Traditional and Community-Integrated), a highly structured academic program (Experimental) or a Montessori program. After a period of seven months the children were evaluated through pre and post-batteries of standardized tests. The Experimental group performed significantly higher than the other groups on the *Stanford-Binet Intelligence Scale* and made significant progress along with the Traditional group on the *Illinois Test of Psycholinguistics*. The Montessori group failed to make gains on either of these tests.

The Montessori program examined by Berger (1969) differed considerably from the implementation evaluated by Karnes, Teska and Hodgins (1970). Even though the children in Berger's Montessori classrooms did not experience the full mixed age range and three years of training basic to the Montessori method, they were taught by certified Montessori teachers in fully accredited classrooms. Karnes, Teska and Hodgins claimed that the Montessori program in their study met Montessori standards, but they failed to identify what organization, if any, had accredited the program and then described a daily schedule resembling a traditional nursery program more than a Montessori preschool. In the Karnes et al. study children only participated in one year of Montessori training beginning at 4 years of age rather than at 3, did not experience mixed age grouping, and only had half an hour of free choice work time as opposed to a two to three hour work period generally found in Montessori preschools. Even though Berger's Montessori program also lacked full implementation, it was considerably more authentic than the

single classroom used as a treatment in Karnes, Teska and Hodgins's study and more adequately represented the gains made possible through Montessori education.

The instrumentation used to measure the gains made by the children in each of the studies also differed significantly. The tests presented to the children in Berger's (1969) study were specifically intended to assess those gains made possible through preschool education and focused on behavior characteristics in addition to cognitive growth. The tests used by Karnes, Teska and Hodgins (1970) exclusively evaluated intellectual and linguistic development and did not attempt to measure desired preschool behavioral acquisitions. Because the testing instruments addressed different criteria, what has been measured must be taken into consideration when interpreting the results of both studies.

Stodolsky and Karlson (1972) examined the differential effects of the Montessori curriculum on disadvantaged children and middle class children. Twenty-nine low socioeconomic children were matched as far as possible with twenty-nine middle-class children in their own classrooms in terms of age, sex, and previous school experience. All the children attended Ancona Montessori School on the south side of Chicago, which was privately run but enrolled a small number of disadvantaged neighborhood children as part of a Head Start program. Children in the study were pre and post-tested on the *Stanford-Binet Intelligence Scale* and those 4 years of age or older were administered the *Wechsler Preschool and Primary Scale of Intelligence (WPPSI)*. At the end of the first year, both the lower and middle-class children showed statistically significant test score gains on both test measures. Children in their second and third years displayed little or no change on the *Stanford-Binet* but did improve on certain measures of the *WPPSI*. Noting that middle-class older children's test scores were similar to the level of the first-year middle-class students, the authors concluded that the older middle-class children must have reached the limits of the Montessori curriculum's effectiveness. They stated

that they had "tentatively demonstrated that the Montessori curriculum is effective over a period of two years in nurturing continuing development in children..." (p. 431).

The sample of children used in this study was small and limited (from only one Montessori school) and the authors failed to specify the teacher's qualifications or the program's accreditation. The classrooms were described as modified although the modifications, such as the inclusion of art supplies and the possibility for children to freely interact, would typically be found in a Montessori environment. The authors discussed why they used the testing measures they did and many of their justifications were based on inaccurate perceptions of what many of the Montessori materials were intended to foster. Stodolsky and Karlson displayed their lack of familiarity with the method by mislabeling the materials as "puzzles" or a "toy". The positive results of the first year students and the subsequent lack of gain demonstrated by the middle class second year students suggests that the Ancona program may have been strong in foundation curriculum but lacked more advanced curriculum applications. The results obtained were not representative of what could be achieved in a fully implemented program, and Stodolsky & Karlson's conclusion that the Montessori early childhood curriculum is exhausted in two years must be taken in view of their limited understanding of the Montessori method.

In a similar study, Guidubaldi, Bersani, Kehle & Sexton (1974) compared the effectiveness of four preschool programs on 3 and 4-year-old children from low and middle class socioeconomic backgrounds. A group of lower income children was obtained and assigned to either a Montessori program or a traditional classroom. A comparable control group without preschool experience was established. A second group of middle socioeconomic status children was obtained and placed into either a Cognitive Model preschool program based on Piagetian theory or a Unit-Based Model, which is an

adaptation of a traditional nursery approach. A comparable control group was obtained for this group as well. Children were administered a battery of tests in the fall and were retested after twenty weeks of treatment. The tests included the *Peabody Picture Vocabulary Test*, the *Dog and Bone Test*, and the *Early Childhood Matching Familiar Figures Test* of the *CATB*, and various subtests of the *WPPSI*. Although the scores of the middle class treatment children were superior to the lower economic status treatment children, all four groups made significant gains on almost all of the dependent variables as compared to the first time they were tested. Because the scores of both the Montessori and Traditional children approached the level obtained by the middle class control group and no differences were found between the low-income treatment groups, the authors concluded that preschool experience in general can be beneficial regardless of socioeconomic status or treatment.

Guidubaldi et al's (1974) scant and overly simplified description of the Montessori method and their failure to describe the program used in the study make it impossible to determine if the treatment the Montessori children received could really be considered Montessori. The authors' failure to include sample size and information pertaining to age and experience of the Montessori children used in the study also diminishes the report's credibility. The poor design of the study--comparing low economic children in two kinds of treatments to middle economic children in two different treatments--adds to the confusion and invalidity of the results.

In a similar study by Wexley, Guidubaldi and Kehle (1974), disadvantaged children in a Montessori program were compared to other disadvantaged children in a traditional day care program as well as to two control groups without preschool experience--one consisting of middle class children and the other of low income children. Eight measures including the *Wide Range Achievement Test*, the *Color Recognition Test*, the *Weight*

Gradation Test, and several subtests from both the *WPPSI*, and the *CATB*, were used to assess aspects of the cognitive development of the four groups of children. While no significant differences were found between the Montessori and Traditional children, the participants of both groups demonstrated significant gains in cognitive performance, scored significantly higher, as determined by the composite factor score, than the disadvantaged control group, and improved on most of the cognitive skills to the point of approaching the level of the advantaged children without preschool experience.

While the design of this study allows for a true comparison to be made between the treatment groups, it is impossible to make accurate conclusions from the results due to the lack of any descriptive information about the programs used in the study.

Early short term comparison studies evaluating the impact of Montessori education on the academic achievement and intellectual ability of disadvantaged children do consistently suggest that Montessori preschool experience is more beneficial than no preschool experience at all. However, when the Montessori method has been compared to other experimental treatments the results have been conflicting. These inconsistencies can be attributed to differing degrees of understanding as to what constitutes authentic Montessori, poorly designed studies, and the short duration of the investigations.

Longitudinal Studies

Several longitudinal studies assessing the learning outcomes of children who have experienced Montessori preschool education provide more consistent results than the short-term studies as to the effectiveness of the Montessori method. A study, which does not specifically assess a Montessori program, has also been included due to the similarity of one of the programs it evaluates with the Montessori method and the significance of

the study's long-term findings. The results of the four studies suggest that there are long-term benefits to Montessori early childhood education.

Miller and Dyer (1975) compared the effects of four prekindergarten programs, Montessori, Traditional, Bereiter-Engelmann (B.E.), an academic drill approach, and Darcee, also an academic program emphasizing direct teaching, on the cognitive, motivational, and perceptual development of culturally disadvantaged four year olds. Children were randomly assigned to experimental classes as they registered for Head Start, and a comparable low-income control group of children not attending preschool was obtained and tested. Teachers were recruited and trained although only two individuals could be found who would complete the Montessori training. This resulted in there only being two Montessori classes in the study whereas each of the other programs was represented by four different classrooms. In addition, the Montessori teachers were younger and less experienced than the other teachers in the study.

The children were administered a battery of tests at the beginning and end of their prekindergarten year. General IQ and achievement were evaluated using the *Stanford-Binet*, the *Preschool Inventory*, and the *Peabody Picture Vocabulary Test*. The *Curiosity Box Test*, the *Replacement Puzzle*, and the *Dog and Bone Test* were used to assess such motivational factors as persistence, distractibility, creativity and the tendency to explore, manipulate, and investigate. The results showed that Montessori children were higher than the others in manipulation and curiosity, but trailed behind the B.E. and Darcee groups in academic achievement and after the B.E. and traditional groups on the *Stanford-Binet*. However, subsequent testing at the end of kindergarten, the 1st grade, and the 2nd grade revealed a pattern favoring the Montessori children in both of these areas. Males who had Montessori preschool and control females had the highest scores

in both IQ and math and reading achievement. The scores of the B.E. group, which initially demonstrated the greatest gains in IQ and achievement, declined the most.

A follow-up study assessing the long-term effects of the four preschool programs was undertaken by Miller and Bizzell (1983). Although depleted by natural attrition, a large enough sample group for each experimental treatment was retained and students were tested on the *Stanford Achievement* test in the 6th, 7th and 8th grade. The *WISC-R* was also administered to the 7th graders and the *Stanford-Binet* at the 8th grade level. While there were no significant differences in IQ at either the 7th or 8th grade level, the Montessori males continued to be highest on IQ and maintained their superiority in both reading and math. The same results were reported in a follow-up study at the 9th and 10-grade level (Miller & Bizzell, 1984), as well as at the 12th grade level (Boehnlein, 1988).

Even though Miller engaged consultants to verify that each program had been adequately implemented, the Montessori program lacked experienced teachers, lasted only a year rather than the customary three years, and did not contain mixed age groupings of children. Despite these problems, Miller's research suggests that Montessori preschool, even when limited, can have long term beneficial results and that immediate academic success is not an accurate indicator of later scholastic achievement.

A similar study by Karnes (1978) followed the progress of five treatment groups-- Montessori, Community-Integrated, Traditional, Bereiter-Engelmann (B-E), and Karnes Ameliorative--over a period of ten years. The Montessori, Community-Integrated, and Traditional groups participated in the Karnes, Teska and Hodgin's (1970) study discussed earlier. At the end of the preschool year, the children in all five groups were tested on the *Stanford-Binet* and the *Illinois Test of Psycholinguistic Abilities (ITPA)*. The B-E and Karnes group's demonstrated substantial gains in mean IQ and improvement in linguistic achievement.

The Montessori children made more modest gains in IQ and were static on the ITPA. Similar results occurred when the groups were retested the following year.

Karnes (1978) continued to track the progress of the B-E, Karnes, and Traditional groups for three more years. By the end of the third grade, the Karnes group scored significantly higher in reading as measured by the *California Achievement Test*, but differences between the three groups on intellectual functioning and language development as a whole had disappeared.

The Montessori children were again included in the ten-year follow-up study initiated by Karnes and her associates. A sample of students from all five groups (approximately 77%) were tested on the *Wechsler Intelligence Scale for Children* and were asked to complete *A Youth Interview*. The parents of these children were asked to give their opinions of the preschool program their child attended using *A Parent Interview*. Results from the WISC IQ test indicated that there were no significant differential effects from any of the five early childhood programs on general intelligence despite initial gains made by the B-E and Karnes groups. On the *Youth Interview*, a higher percentage of Montessori students responded that they were doing better, overall, than others in their schoolwork. A much higher percentage (77%) also stated that they got along very well with other family members. Approximately 85% of the parents of children who had enrolled in the preschool study completed the *Parent Interview*. While the majority of parents responded favorably to the question, "Was the program a good thing for your child?", all of the Montessori parents answered this in the affirmative.

The Montessori children in Karne's study only received one year of Montessori experience and were exposed to a shorter individual work period than is usually found in Montessori classrooms. Despite the lack of exposure to a full program, the Montessori children maintained their academic gains over time, demonstrated greater self-confidence, and reported better interpersonal relationships at home.

The third year results of a comparison of four groups of children were reported by Gross, Green & Clapp (1970). The study, originally initiated by Banta (1969), included reasonably matched children in terms of age, race, gender, and socioeconomic status. The four programs consisted of a Montessori classroom, a nongraded classroom, and two graded classrooms--one with children with preschool experience, the other composed of children without preschool experience. Traditional intelligence-achievement dimensions were evaluated during the first and second years of the study while aspects of social competence, maturity, and self-concept were assessed in the third year report. Nonacademic data was secured through interviews with children, parents, and both Montessori and nongraded teachers. Children were asked specific questions such as what they liked and disliked about themselves, and were rated by an interviewer on such items as "comfortable in adult company" to "communicates with effort". A reliability rating was given for only one of the testing measures used. While there were no differences between the groups on measures of self-concept, the Montessori children were found to be much more extroverted, verbal, and personable than the other three groups of children and "had more to say, could express it better, and had fewer articulation problems than the other children" (p. 6). The authors concluded that the Montessori children's superior communication ability would have obvious implications for academic achievement and interpersonal relationships. These findings, however, should be taken with caution considering the small sample sizes and the lack of information pertaining to the reliability of the interviewing measures used.

Schweinhart, Weikart & Lerner (1986) explored the consequences of three preschool curriculum models through the age of 15. Sixty-eight disadvantaged 3 and 4-year-old children were randomly assigned to three prekindergarten models: Distar, a direct instruction program; High/Scope, a cognitively oriented approach; and a traditional

nursery school program. The children demonstrated little variation on IQ and academic achievement over time, but differed significantly in social behavior when interviewed at the age of 15. On an 18-item delinquency scale, students who were members of the Distar group reported engaging in twice as many delinquent acts, including five times as many acts of property violence, as did members of the other two groups. Drug abuse, poor family relations, less participation in sports, lower expectations for educational attainment, and twice as many acts of personal violence were reported by the Distar group. The authors conclude from this study that there are important social consequences to preschool curriculum choices and that those programs emphasizing direct transmission of knowledge are "less successful in helping children adapt to the interpersonal realities of rules and conventions" (p. 42). They suggest that the definition of a high-quality preschool curriculum needs to be redefined and that it must be based on child-initiated learning activities.

The results of Schweinhart, Weikart, and Larner's study are significant because they suggest that what a child experiences in his or her preschool years could have a profound influence on the child's social relations and degree of self-control for many years to come. The fact that the Montessori curriculum is based on child-initiated learning activities suggests that similar outcomes as those demonstrated by the High/Scope group would be possible. This was alluded to in Karnes' (1978) follow-up study where the Montessori children were identified as being more confident in their academic abilities and more likely to relate well with other family members.

Research on the effectiveness of the Montessori method over time suggests that early exposure, even when limited, can produce lasting positive benefits. Disadvantaged Montessori children who were evaluated later in their schooling years maintained initial academic gains made during preschool (Miller & Bizzell, 1983, 1984; Miller & Dyer,

1975; Karnes, 1978; Reich, 1974) and demonstrated positive behavioral characteristics (Karnes, 1978, Gross et al., 1970). The results from Schweinhart, Weikart & Larner's study validate these findings and support the premise that child-initiated preschool curriculums are more beneficial to children than teacher-directed programs.

Social Development

A frequent criticism of the Montessori method is that the independent nature of many of the classroom activities would hinder the child in his or her social development. Research in this area does not support this assumption (Baines & Snortum, 1973; Berk, 1973; Flynn, 1990; Gross, Green & Clapp, 1970; Murphy & Goldner, 1976; Reuter & Yunik, 1973; Villegas, 1988). A number of studies specifically aimed at assessing the Montessori child's development of social skills suggest that social interaction is an integral part of the Montessori environment and that growth in this area increases with time in the Montessori classroom. Comparative studies suggest that Montessori training not only fosters the acquisition of social skills, but that it is more effective at doing so than other preschool programs (Baines & Snortum, 1973; Gross, Green & Clapp, 1970; Reuter & Yunik, 1973).

Reuter and Yunik (1973) examined the social interactions of children in a Montessori program, a university laboratory preschool, and a parent cooperative nursery school. Children were predominantly from white, middle class backgrounds and ranged in age from three to six years. The Montessori school was AMI accredited and had a child to adult ratio of 1 to 12. The other two early childhood programs had child/adult ratios of 3.5 to 1. Data was collected using a social interaction observation procedure and involved measuring the frequency of verbal and nonverbal behavior directed toward another person, recording who initiated and responded in the interaction, and noting the

occurrence of behaviors considered incompatible with continued social interactions, e.g. crying, kicking, etc. Montessori children were found to interact more with their peers and for longer periods of time. The researchers concluded that longer interactions were desirable because they required more verbal ability and a greater capacity for cooperation, but acknowledged that the results of the study needed to be taken with caution considering the differences in child to adult ratios within the three programs.

Murphy and Goldner (1976) replicated and extended Reuter and Yunik's (1973) study controlling for the effects of the child/adult ratio and also found that Montessori children interacted for longer periods than the comparison group and spent a greater portion of time interacting verbally. Murphy and Goldner (1976) concluded that a high child/adult ratio may inhibit the development of peer-oriented interpersonal skills and that the greater percentage of free time in the Montessori classroom increased the total amount of time for social interactions to occur.

The activities that took place in different preschool settings were explored by Laura Berk (1973). Six preschool programs were compared including a Montessori preschool, a Head Start program, two laboratory nursery school classrooms, a franchised day care center, and a community day care center. The Montessori class consisted of 23 middle class children who were three and four years of age. Berk found that disruptive behavior was at a minimum in the Montessori classroom and that the program's emphasis on individual activities did not diminish the children's interactions with one another. The Montessori classroom provided more opportunities for socialization than any of the other programs studied. Baines and Snortum (1973) also found that Montessori children spent a greater portion of time in activities that fostered social development in their study comparing Montessori children to public school children.

The length of time in a Montessori environment was shown to have had a positive effect on children's social interactions. Flynn (1990) compared 108 AMI Montessori children with 116 traditional preschool children to determine the effectiveness of each program on its participant's development of social, personal, and cognitive skills. The Montessori and traditionally schooled children were rated by their teachers using the *Pre Kindergarten Scale (PKS)* developed by Flynn. The *PKS* measures social, personal, and cognitive skills by describing a classroom situation and then providing four possible behaviors one of which the teacher chooses to best describe how a particular child would normally respond. In addition to finding that relationship with peers correlated positively with length of time in the Montessori program (with age controlled), Flynn also found a significant relationship between personal skills, behavior control, cognitive skill, and length of time in the program for Montessori children but not for the traditionally schooled children.

The socialization of children in an AMI public early childhood Montessori classroom was investigated and described in an ethnographic study by Villegas (1988). Thirty-one children in an ethnically mixed, fully implemented Montessori classroom were observed. Data for the report was collected by trained observers between the months of August and December with the class being observed a total of 35 times for an entire half day session. The information obtained was then analyzed for patterns. The Montessori children in this classroom were found to have a strong sense of individualism and an equally strong sense of community. They worked at their own pace, were open to cooperation and helping one another, and shared responsibility for maintaining order in the classroom.

Research aimed at assessing the social skills of children in Montessori early childhood education suggests that the Montessori environment successfully fosters the

development of positive social interactions and peer-oriented interpersonal skills.

Montessori children in fully accredited AMI Montessori classrooms were found to be more verbal, less disruptive, and more apt to sustain interactions than children in other early childhood programs.

Test Score Comparison Studies

Despite the proliferation of public school elementary Montessori programs, few studies have been initiated to assess their effectiveness. The research, which has been attempted in recent years, has consisted primarily of standardized test score comparison studies between Montessori children, in either private or public Montessori schools, and their non-Montessori peers. Interviews in which teachers were asked to compare the classroom behavior of Montessori students to their classmates were included in the designs of two of these studies. The test scores that have been examined and teacher interview results have consistently favored the Montessori children.

Takacs and Clifford (1988) compared the *California Achievement Test* scores of 58 economically disadvantaged children who had attended a public Montessori preschool program with the test scores of their classmates in a regular public school program. The children studied were located in 17 different elementary buildings and 47 teachers were interviewed. The mean scores of the Montessori group in both math and reading were significantly above the mean scores of the non-Montessori children. In reading, the Montessori children scored at the 62nd percentile while the mean ranking for the non-Montessori group was at the 48th percentile. The 16 Montessori subjects tested in math obtained a mean score at the 64th percentile as compared to a mean ranking at the 50th percentile by their non-Montessori classmates. One third of the Montessori graduates scored high enough to be considered for selection into a citywide program for gifted and

talented learners. In addition, Montessori students were rated by their teachers as significantly above their classmates in regular attendance, time on task, independent work habits, and task persistence.

Duax (1988) used a similar approach to assess the achievement of 84 public school Montessori graduates. All the children in the study began the program at MacDowell Montessori School at four years of age and graduated at the age of eleven. Half of the children were ethnic minorities and 36% were low income. The school they attended was a magnet school within the Milwaukee public system and was recognized by AMI as making "significant strides toward the full implementation of Montessori theory and practice" (p. 57).

Test score comparison results revealed that 84% of the MacDowell graduates scored above the 50th percentile with 45% obtaining stanine scores at the high achievement level. Survey results were equally encouraging. The 27 different middle school teachers who completed the surveys consistently rated the Montessori students above average as compared to their peers. The MacDowell graduates scored particularly high in the areas of preparedness, motivation, self-assurance, and positive human relations.

Similar studies were conducted by DeJong (1985), Glenn (1989) and Staskey and Chester (1987) comparing students who had private Montessori school experience to public school children without Montessori early childhood or elementary experience. They concluded that Montessori children do as well as, or in most cases better than, their public school peers on standardized tests, and that the more Montessori education a child experiences the greater the effects.

Some caution must be exercised when interpreting the outcomes of the test score comparison studies. Selection bias must be considered as a possible influence on the

positive results obtained. Parents who select Montessori education for their child could differ in some fundamental way, such as level of education, from parents who do not make this choice for their child. The lack of random assignment in all of these studies makes it impossible to conclude that the beneficial outcomes for the Montessori students were specifically due to their Montessori experiences. The fact that students were assessed from only one Montessori school in each of the studies must also be taken into account. Even with these factors in mind, the results of these comparisons are impressive and carry additional significance since they were obtained from fully implemented Montessori programs. They corroborate the findings of earlier studies and provide strong evidence that the Montessori approach is educationally effective.

Conclusion

Due to the scarcity of Montessori research available at the elementary level, it was necessary to also review studies focused on Montessori early childhood education in order to assess the effectiveness of the method. Many of the earliest studies involving Montessori education sought to compare the influence of different preschool approaches on the intellectual and academic development of low socioeconomic children. The Montessori programs included in these studies varied considerably in their authenticity and the results obtained reflected this--more adequately implemented Montessori programs produced more favorable outcomes. The longitudinal studies reviewed fulfilled the need for evaluating the long-term benefits of Montessori preschool experience. The findings suggest that Montessori children are able to maintain the academic gains made in preschool over time and that programs such as Montessori which are based on child-initiated activities help develop self-control and are beneficial to children's interpersonal relationships. Research on social interactions in Montessori classrooms helps to refute

the belief that Montessori education hinders the development of social skills. The Montessori environment was found to not only foster socialization, but to do so more effectively than many other early childhood programs tested. Most recent research assessing the academic performance of elementary and public Montessori students has been based on test score comparisons. Children with public Montessori experience at both the early childhood and elementary level obtained significantly higher standardized test scores and substantially better behavioral ratings than their non-Montessori classmates.

In summary, research on Montessori education provides strong evidence that the method is beneficial to children's cognitive, academic, and social development. Research suggests that Montessori children, including those from low socioeconomic backgrounds, are able to maintain the gains made in preschool over time and that longer exposure to the approach produces more significant results. Many of the studies also suggest that the method enhances the acquisition of beneficial behavior skills such as persistence, independence, motivation, and positive human relations.

The growth of Montessori in the public sector implies that the approach is compatible with educational reform in this country. Research on Montessori suggests that the method is also a highly effective educational alternative to traditional public school practices. While these findings can be interpreted as strongly supporting the expansion of Montessori in the public sector, they also provide insight into how future Montessori programs should be established. Just as poorly implemented Montessori programs compromised the effectiveness of the method as indicated by early research results, public school Montessori programs will not benefit children to the greatest extent possible if they are improperly implemented. Montessori programs in public education

will need to adhere to authentic Montessori standards and should not be compromised in an attempt to conform to traditional practices.

The need for more research on the Montessori method at the elementary level and in public education is obvious. Long-term assessments are needed as well as studies that involve more than just one Montessori classroom or school. Also needed is research that addresses the specific goals of Montessori education and studies that evaluate students with measures other than standardized tests, which are severely limited in what they assess. Research initiated to identify the elements which make the Montessori approach unique would also help to promote understanding of the method.

HISTORY-SOCIAL SCIENCE CURRICULUM COMPARISON

The State History-Social Science Curriculum

The California history-social science curriculum, adopted by the California State Board of Education in 1987, is described in a document entitled the *History-Social Science Framework for California Public Schools, Kindergarten Through Grade Twelve*. Developed by a committee of teachers, administrators, curriculum specialists, and faculty of higher education, the *History-Social Science Framework* is to be used as a guide for curriculum planning and as a means for influencing the development of instructional material. The document outlines the distinguishing characteristics of the history-social science framework, discusses the curriculum's major goals and objectives, and provides a description of the course work to be covered at each level from kindergarten through the twelfth grade.

The introduction of the *History-Social Science Framework* states that the main focus of the curriculum is the study of continuity and change with an emphasis on the central importance of history within the social sciences and humanities. It is the intent of the curriculum to provide the knowledge and understanding necessary for our students to function intelligently now and in the future and to help students gain an understanding of individual and social ethics. The introduction describes the *History-Social Science Framework* as:

1. A chronological study of history.
2. An integrated and correlated approach.
3. Emphasizing the importance of history as a story well told.
4. Using literature to enrich the study of history.

5. Introducing a new curricular approach for the early grades emphasizing the use of imagination to ignite an interest in history.
6. Studying major historical events and periods in depth.
7. A sequential curriculum.
8. Incorporating a multicultural perspective.
9. Increasing the place of world history in the curriculum to three years.
10. Emphasizing the importance of ethical understanding.
11. Encouraging the development of civic and democratic values.
12. Frequent study of fundamental principles in the U.S. Constitution & Bill of Rights.
13. Presenting controversial issues.
14. Acknowledging the importance of religion in human history.
15. Including critical thinking skills at every level.
16. Actively engaging students in the learning process.
17. Providing opportunities for participation in school & community service programs.

Curriculum Goals and Strands

There are three categories of goals discussed in the *History-Social Science Framework*. Each category is subdivided into curriculum strands and each strand is described in the framework in terms of the basic understandings students need to obtain to fulfill the requirements of the strand. The basic learnings introduced in the curriculum strands are to be integrated and correlated by the teacher in every grade unifying the curriculum across all the grades. The three categories of goals and their curriculum strands are as follows:

Goal of Knowledge & Cultural Understanding

Historical Literacy

Ethical Literacy

Cultural Literacy

Geographical Literacy

Economic Literacy

Sociopolitical Literacy

Goal of Democratic Understanding & Civic Values

National Identity

Constitutional Heritage

Civic Values, Rights, & Responsibilities

Goal of Skills Attainment & Social Participation

Basic Study Skills

Critical Thinking Skills

Participation Skills

The course descriptions contained in the *History-Social Science Framework* are intended to sequentially develop and integrate the goals of the curriculum. The curriculum is divided into three levels: (a) the primary curriculum, encompassing kindergarten through grade three; (b) the middle grade curriculum, consisting of grades four through eight; and (c) the secondary curriculum, covering grades nine through twelve. Each level is subdivided by grade and each grade has a course title and major subtitles. The content of the curriculum for each grade is described and learning activity suggestions are provided.

The Primary Curriculum

The primary history-social sciences curriculum is described in the framework as extending the child's spatial, temporal, and casual understandings by exploring into the

past and reconnecting into the immediate present. Children are introduced to people of past times to help build their sensitivity and appreciation for the human experience, and important links are made with the larger geographic and economic world.

During the kindergarten year, the curriculum focuses on learning how to work together, exploring the child's school and community, and developing a sense of historical empathy. Children should be given opportunities to problem solve and are introduced to stories and fairy tales incorporating conflict and value issues. Their sense of self and self-worth is extended by developing an understanding of their immediate world and by allowing them to assume individual and group responsibilities.

Opportunities to build and improvise using a variety of materials are to be provided and children should be encouraged to replicate neighborhood structures in their group play. Well-selected stories from times past are used to expose students to the different ways people have lived and as a base for comparing how these differ from the life styles of today.

The first grade curriculum continues to develop the child's social skills and responsibilities, expands the child's geographic and economic understanding, and explores cultural diversity. Conflict resolution through problem solving is continued and appropriate stories and fairy tales are used to involve students in discussions of value-laden problems and to provide opportunities for role-playing. The community will be explored in more depth at this level and children will be encouraged to build three-dimensional maps of their immediate geographic regions. The interconnectedness of their surroundings with the larger world as well as basic economic understandings will also be studied. Cultural diversity should be introduced through literature focusing on the cultures represented by the children themselves. Stories of men and women who are heroes should also be read.

In the second grade, the history-social science curriculum focuses on the people who have made a difference directly and indirectly in the child's life. The interdependence of all people will be explored with an emphasis placed on the study of those who produce our food. Students will be introduced to map reading, exploring geographic cause and effect relationships, and the importance of international trade. Children will also explore their own family backgrounds and construct a family history. Literature will be used to introduce students to the famous as well as ordinary people who have made a difference in their lives.

During the third grade, children will investigate continuity and change in their own locality and will explore our national history through legends, folktales, biographies, and stories. The local history unit will focus on the study of the natural landscape (including the construction of a terrain model of the region's topography), the first inhabitants of the area, the impact of each new group to the region, and important influencing events. Children should have opportunities to role-play and to explore historical photographs and literature that illustrates how people lived at an earlier time. Classic American folktales, legends, tall tales, and hero stories will be studied to build a sense of national continuity and community.

The Middle Grades Curriculum

The middle grades history-social science curriculum explores the development of major Western and non-Western civilizations. The framework describes children at this level as being able to think more abstractly and recommends exercising their analytical thought processes using concrete instructional materials such as maps, time lines, and charts. Historical periods should be studied in depth and an emphasis placed on learning about the lives of people who lived in the past

The fourth grade history-social science curriculum focuses on the state of California. Students will begin their study by exploring California's geography and Native American culture, and continue by chronologically examining the people and events that have shaped the state's history. A time line should be constructed to organize these events, and each period explored should be brought to life through the use of literature, songs, and dramatizations. Students will also study the development of modern California and examine the unresolved problems facing the state today.

During the fifth grade students are introduced to the history of the United States. Students will examine the development of the nation emphasizing the major pre-Columbian settlements, the early European explorers, the Colonial period, the events leading to the Revolutionary War, life in the early American republic, and the nation's westward expansion. Whenever possible, students should explore biographies, journals, and diaries to help them see these events through the eyes of the people who experienced them. Other forms of literature, including folktales and historical fiction, as well as dramatizations and the reading of excerpts from speeches should be used to help deepen students' understanding of the historical periods examined. The nation's founding principles and the contributions of the different groups of people who have built the American nation will also be investigated.

In the sixth grade students are introduced to the ancient civilizations of the world. Beginning with a survey of prehistoric people, students will proceed by examining the first civilizations in the Near East and Africa, the ancient Hebrews and Greeks, the early civilizations of India and China, and the Roman Republic. Students will explore the geographic significance of these early civilizations and will examine their major contributions, achievements, and belief systems. Critical thinking will be emphasized and students should be encouraged to engage in comparative analysis between cultures and over time. Factors of continuity and change should be considered as well as the

influence these early cultures have had on Western Civilization and our own lives today. Students should study the art, literature, and ethical teachings of these cultures and be introduced to the major figures that shaped these early societies.

The seventh grade history-social science curriculum continues the study of world history beginning with an examination of the ways archaeologists and historians uncover the past. Students will then review the Roman Empire and its fall followed by units on: (a) the growth of Islam, (b) the African States during the Middle Ages and in early modern times, (c) the civilizations of the Americas, China, Japan, Medieval and Renaissance Europe, (d) the Reformation and the Scientific Revolution, and (e) early modern Europe including the age of exploration and the enlightenment. Students should be encouraged to develop maps and time lines to place these events in time and place, and to enable them to compare events occurring concurrently in the world. To link the past to the present, students will consider the ways ideas formulated in these earlier times have influenced our nation and the world today.

During the eighth grade, students will continue their study of United States history and geography. The study begins with a review of significant events in early American history followed by an investigation of the shaping of the Constitution and the nature of the government it created. The regional development of the United States will then be considered and the events leading to and immediately following the Civil War. The course of study will conclude with an examination of the rise of industrial America and an analysis of the transformation of social conditions in the United States from 1914 until the present.

The *History-Social Science Framework* concludes with a section describing criteria for evaluating instructional materials based on the recommendations provided throughout the document. Basic guidelines to be used in considering textbooks and other

instructional materials are provided as well as recommendations for the organization of materials, teacher's manuals and reference materials, assessment and evaluation, and instructional media.

The Montessori History-Social Science Curriculum

Maria Montessori first introduced her history-social science curriculum, a component of her elementary curriculum referred to as cosmic education, during a training session in London in 1935. While interned in India during World War II she further developed the curriculum, and in 1948 published her ideas in a book entitled *To Educate the Human Potential*. While the book does provide a rationale for cosmic education and ideas for how the plan can be presented to children, it does not provide specific course descriptions. Details of the curriculum are presented to teachers as they train in Montessori education and are either written up by the trainee in a lesson plan format or are already printed and assembled for the teachers use by the training institute. The nature of the plan as a framework for exploration rather than a detailed course of study has helped to maintain the curriculum's stability and applicability over time.

The Montessori elementary history-social science curriculum focuses on showing the unity of all things in order to help the child establish an interconnected system of knowledge. Rather than beginning with the child's immediate environment and working toward a broader perspective as is frequently done in traditional education, the Montessori approach begins with a picture of the whole--the creation of the universe--and gradually works toward the child's own culture. Subject material is presented in key lessons to ignite the enthusiasm of the student and functions as a starting point from which the child can systematically explore according to his or her own interests. The curriculum serves as a basis for every subject taught in the elementary classroom and is

closely aligned with the Montessori biology and geography curriculums. Through this holistic approach the student is introduced to the inherent order of the cosmos and is lead to discover cause and effect principles that have influenced the evolution of life on our planet.

The elementary Montessori history-social science curriculum, as with every Montessori subject area, is structured around the psychological characteristics of children at this level (Lillard, 1996). According to Montessori, during the first six years of life, the child explores sensorially and constructs herself by taking in the totality of life around her including the customs, culture, and psychological climate of her environment. At the elementary level, the child develops a reasoning mind that allows her to research and retain knowledge using thought, imagination, and creativity. The elementary student enjoys intellectual activity, has an enormous potential for work, and is able to manipulate ideas to solve problems and understand phenomena. An interest in the unusual and extraordinary is characteristic of this level as is a preoccupation with completing large works and with the concept of infinity.

Moral reasoning begins to function at this level and the student becomes concerned with rules and fair play. What is considered acceptable in society becomes important to the child and she displays an interest in exercising her own moral judgment in determining what is right and wrong. A tendency toward hero worship also becomes evident during the elementary years and the child exhibits a strong desire to be with her peers. Group affiliation becomes important to the student and she enjoys cooperative work and social interaction.

To cater to these characteristics, the Montessori history-social sciences curriculum systematically explores the evolutionary process of life through the use of imaginative and impressionistic materials that arouse the child's interest and curiosity. Key lessons are presented to small groups and the student is free to respond with his own follow-up or

not at all. Research in the community is encouraged and children are given opportunities to work with one another on projects of their own choosing. Frequent social interactions and freedom within the classroom provides the children with opportunities to exercise their own judgment and to become responsible for their own actions. By studying the earth and its inhabitants the student forms an appreciation for the "cosmic plan" of life and is led to a better understanding of his world and his own place within it.

Early Childhood Preparation for Cosmic Education

The elementary Montessori child is prepared for cosmic education at the elementary level by sensorially exploring culture in the early childhood Montessori classroom. According to Montessori, the child at the preschool level is working on self-construction and is interested in learning facts. She is inquisitive and naturally drawn to explore, indiscriminately absorbs information from the environment, and learns through activity (Montessori, 1973b). To respond to the preschool child's developmental characteristics and to help foster the child's cultural acquisition, the 2 1/2 to 6 year-old is introduced to the Montessori cultural subjects. These subjects, which include art, music, geography, history, zoology, botany, and peoples of the world, help the child to define her world and promote the development of a global view. They help to illustrate how various aspects of nature integrate into the whole and assist the child in seeing herself in relation to the rest of the world. The child learns about her own culture as well as the cultures of others and is helped to realize the great variety of peoples that inhabit our planet.

Cultural subjects are presented to the child using concrete materials that can be manipulated and explored. Small group or individual presentations are given to help guide the child in her use of a material, and a built in control of error enables the child to determine for herself whether a task has been completed successfully or not. The child's

interests and developmental level determines what materials are presented and the child is free to work with these activities at her own choosing. Core presentations serve as only an introduction to an area of study and should be extended by the teacher according to the interests of her children.

The child in the preschool Montessori classroom is directly prepared for cosmic education through a study of the natural and social sciences. Specific exercises in geography and biology form a basis for such an investigation and are extended through teacher-developed units in geology, astronomy, chemistry, physics, anatomy, etc. A presentation distinguishing between living and non-living entities introduces the primary child to science in the classroom and is generally followed by an activity exploring the three coverings of the earth--water, land and air. A study of geography will usually be initiated at this point although the order of subsequent presentations will differ depending on the teacher or school.

Geography

Both physical and political geography are introduced to the child in the Montessori preschool classroom. Clay models in which water can be poured actively involve the child in a study of land and water formations. A tactile globe with blue oceans and brown, sand covered continents extends the concept of land and water to our earth, while a similar globe with painted land masses introduces the child to the different continents of our world. An in-depth study of each continent using puzzle maps, picture material, miniature flags, artifacts, etc. introduces the child to the many cultures and peoples that coexist on our earth. An exploration into the needs of people helps the child to recognize existing commonalties between all people.

Biology

Biology is first presented in the Montessori early childhood classroom through a plant and animal classification activity. Zoology is explored by a study of the five main classes of animals--fish, amphibians, reptiles, birds, and mammals--as well as through the study of various invertebrate. Live animal presentations, numerous sorting, matching and sequencing activities, and the use of corresponding puzzles, books, games, and body part card material serve to familiarize the child with each class of animal under investigation. The botany curriculum is less comprehensive at this level and consists of card material to introduce the parts of the plant and a sensorial introduction to the different shapes of leaves using a drawer cabinet containing 14 different leaf shapes. Numerous other botany activities can be initiated in the classroom and can be organized according to which activities are most appropriate at different times of the year.

The geography and biology activities introduced in the Montessori preschool class provide a foundation for related scientific studies. Basic physics experiments can be presented at this level to familiarize the child with the natural laws that govern our existence on earth. Geology activities structured around the study of rocks or the layers of the earth help to acquaint the child with the composition of our planet. A study of astronomy focusing on the solar system and the stars encourages a sense of wonder about our universe and prepares the child for the story of its creation in the elementary Montessori classroom. Almost any area of the natural sciences can be presented to the child at this level provided that the lessons are appropriately simplified and actively involve the child with concrete materials.

While the child's direct preparation for cosmic education is provided through natural science and social studies investigations, indirect preparation is obtained through numerous activities in the early childhood classroom including music, art, practical life,

and telling time exercises. These subjects help the child adapt to her own culture and provide a means for exposing the child to the cultures of others. They help to build the concentration and skills the child will need in her study of cosmic education, and help the child to foster an appreciation of our cultural heritage.

The Montessori Elementary Curriculum

The Montessori elementary history-social science curriculum is divided into four sections: (a) natural history, (b) pre-history, (c) written history, and (d) the linear measurement of time. The first three sections are presented to the student chronologically. The fourth, the linear measurement of time, can be explored in conjunction with the study of natural history to provide a foundation for the child's later pre-history and written history work. The curriculum does not specify at what age or grade level a topic should be presented, but does state prerequisite work where appropriate. Materials used in each presentation are either provided by Montessori training programs, made by the teacher's themselves, or purchased from a Montessori material distributor. A description of economic geography, which forms part of the Montessori geography curriculum rather than history, is included here because of its relevance to the social sciences.

Natural History

The study of history begins with a story of how the earth came to be. Factual information is presented within the tale to awaken the interest of the child and simple experiments and charts are used to help the student visualize how his world came to be and how it continues to function. Follow-up work from the story continues in two directions--through a study of geography, which explores facets of the earth's formation

including the role of matter, the laws of gravity and attraction, and the work of air and water in shaping the surface of our planet, and through a study of natural history.

Natural history is presented to the student as the earth's preparation for the coming of humanity. The lessons are meant to give an impression of the enormous amount of time this preparation has taken and are intended to excite the child about what happened long ago. Three materials are used to convey this idea: (a) the black strip, (b) the clock of the eras, and (c) the evolution time-line.

The black strip, which is 30 meters long and all black except for a red centimeter at one end, is slowly unrolled in front of the students to emphasize the immensity of time the earth's preparation has taken and the relatively short period of time humans have inhabited the planet. Important events in the earth's creation are told as the strip is unrolled, and the small bit of red appearing at the end is explained as representing mankind's existence on the earth. The clock of eras represents the planet's history in geological time and is presented by giving more specific information about what happened on the earth before the arrival of humans. Finally, a detailed account of what may have happened during the different eras in the earth's development is presented with the evolution time line. Unlike the black strip and the clock of eras which are explained in one presentation, the evolution time-line is used as an ongoing study and referred back to time and again as the students work their way through the geological periods of our planet's history. This in-depth investigation traces the earth's history of geological and biological changes and emphasizes the harmony that has existed in nature over time.

Pre-History

The arrival of man at the end of the evolution time line prepares the student for the next area of study--pre-history. The study of pre-history examines the early development

of mankind through the use of five materials: (a) the hand chart, (b) the fundamental needs of man chart, (c) the first and second time lines of human beings, and (d) the history question charts.

The hand chart, which resembles the black strip in appearance, gives an impression of the enormous amount of time man's total development has taken in comparison to the small portion of time that mankind has been able to write. The fundamental needs of man chart is used to illustrate that all people have the same needs, but that these needs have been met in different ways depending on where and when people have lived. This concept of fundamental needs will guide the student's study of history and social sciences and will come to be seen as the determining factor in how societies have developed. Additional charts, exploring a specific need such as food, may also be presented or made by the children themselves.

The first time line of human beings explores the Paleolithic period and how early humans used their faculties to fulfill their needs and adapt to their surroundings. Extensive follow-up work, including the construction of models and dramatizations, can be introduced to help students visualize what life may have been like during that time. The second time line of human beings is then introduced. This time line focuses on the Upper Paleolithic period and explores the agrarian revolution and the development of civilizations. Early settlements and civilizations are studied in detail and the time line functions as a reference material that is referred to each time new topics are taken up for study. The history question charts help to guide the child's study of this period by requiring that the student match separate answer cards with their appropriate questions. The questions can later be used to help the child initiate and organize her own research projects.

Written History

The study of written history focuses on the growth of culture, the exploration of ancient civilizations at the 8, 9 and 10 year-old level, and the study of later history, including U.S. and local history, at the 10, 11 and 12 year-old level. The growth of culture is examined through the use of the migration charts, which impressionistically illustrate the reasons groups of people have migrated. History studies are organized around the interests of the students and involve choosing topics, gathering information, and sharing what has been found. Additional activities include:

1. Locating a civilization on a map and studying its geographic features.
2. Mentioning famous personalities and telling stories about people.
3. Contrasting the civilization with its golden age with its present form.
4. Displaying artifacts.
5. Inviting resource people to come in.
6. Making charts, i.e. of animals, food, etc.
7. Developing a file folder with pictures and captions.
8. Learning about the written language; contrasting it with other alphabets.
9. Tracing maps of the area; noting major cities and geographic features.
10. Going out into the community, e.g. museums, displays, etc.
11. Constructing a time line as a group.
12. Having folders available with answers to the history question charts.
13. Completing arts and crafts projects related to the study.
14. Making booklets of words that come from the civilization.

The study of American history begins with a discussion of how the North American continent became populated and continues with a chronological study of our countries

development through the use of an American history time line. The time line is composed of eight panels and each panel forms a unit of study. Students choose their own topics for research and follow-up activities, such as visiting museums, map making, dramatizations, arts and crafts projects, etc., are encouraged. The American history time line panels are divided into the following topics:

American Aborigines

Native Americans

Period of Exploration: 1492-1607

Colonial Period: 1607-1776

The New Nation: 1776-1881

Reform and Reconstruction: 1861-1914

A World of Power: 1914-present

Measurement of Time

During the study of the measurement of time the student examines techniques for graphing time on paper and is introduced to the etymology of the language of time measurement. Learning to tell time using our twelve-hour clock is explored and the child is introduced to the days of the week and the months of the year. The concept of a time line is explored by assembling a class diary in linear fashion and through the creation of a family time line, a personal time line, and a B.C. - A.D. time line. The history of personal names is also investigated in this unit.

Economic Geography

The child's work in economic geography focuses on the production, consumption, and exchange of goods, and the interdependence of humans in society. Rubber product

stamps and outline maps actively involve the student in a study of production while simple graphing techniques help the student to investigate consumption and the exchange of goods first nationally, then on a world wide basis. The child's study of interdependence begins with the story of bread and focuses on the many people involved in the process through the use of picture cards. The contributions and then the needs of the farmer are considered to illustrate the interconnectedness of people and services and that to satisfy our needs we have to depend on many other people.

Coverage of the Public School Curriculum

In addition to the child's work in cosmic education, it is expected that the elementary Montessori student will also complete the requirements of the public school curriculum. This enables the student to follow her own interests while at the same time developing competence in the academic areas deemed important to society. In most cases, the child's work in the Montessori classroom will encompass these requirements although not necessarily within the same framework as in public education.

The State and Montessori History-Social Science Curriculums Compared

Both the California public school and Montessori history social-science curriculums attempt to prepare the child with the knowledge and skills necessary for fully functioning in our society. Despite many differences in how each approach tries to achieve this goal, the two curriculums do have some characteristics in common.

Similarities

Both the state and Montessori history-social science curriculums include the study of Western and non-Western societies, and the importance of religion in human history is

acknowledged by each approach. Some subject material, such as the interdependence of humans and United States history, is introduced at approximately the same time in the state as well as in the Montessori curriculum, and both systems encourage the presentation of controversial issues in an honest and sensitive manner. Actively engaging students in the learning process and the development of critical thinking skills is recognized as important by each approach, and both systems value the cultivation of behaviors necessary for functioning in our democratic society. Literature is used to enrich the study of history and to excite the child's imagination in both curriculums and participation in school and community service programs and activities is encouraged by the state and within the Montessori system of education. While the two curriculums may vary in the way and extent to which these factors are implemented, both approaches view these features as important and have sought to integrate them into their design.

Differences

Despite some features in common, the general approach toward the teaching of history-social science assumed by the state is significantly different from the method used in the Montessori system of education. The primary areas of difference include: (a) the unifying element within the curriculum, (b) factors considered in curriculum development, (c) how the curriculum influences instruction, (d) the approach each uses to introduce multiculturalism, and (e) the concept of "chronological study" each adheres to.

Unifying Element

One area of difference between the state and Montessori approach to history-social science education is how each curriculum is structured and unified. The state curriculum's

three primary goals are divided into strands of basic learnings unifying the curriculum across all grades. Each of the twelve strands, which are further subdivided into corresponding objectives, is to be included and integrated in the teaching of history and social studies in every grade. The detailed course descriptions provided in the framework develop and integrate the goals of the curriculum and correlate the teaching of history with the other humanities and such academic areas as the language arts and science. The study of continuity and change is the main focus of the curriculum and is emphasized by exploring the forces that have produced change and maintained continuity over time.

The unifying element in the Montessori curriculum is the vision of the universe and the interconnectedness of all life. The history social-science curriculum provides a framework for systematically acquiring knowledge related to the "whole" and emphasizes the child's self-development through mental activity rather than specific academic goals and objectives. While the state curriculum decides the content of the material introduced at each grade level, it is the child's interests that determine what information will be explored in relation to key presentations in the Montessori classroom. The student's chosen work may extend into other academic areas and every subject area introduced in the classroom ties into the history-social sciences curriculum. Knowledge is gained in a logical manner and the child's learning, derived through her own efforts, becomes organized into a coherent whole.

Development Criteria

A second difference between the two curriculums is the criteria used as a base for the formation of each. The state's present *History-Social Sciences Framework* was developed by a committee of professionals attempting to improve the previous curriculum by considering current research and student interest and achievement in the

subject. Curricular goals were established in terms of the knowledge, skills, and understandings children should acquire in this subject area, and detailed course descriptions were developed as a means for fulfilling these objectives. The content of each grade is geared toward what the child needs to know or should learn at that level and is loosely built on the child's previous learnings from the year before. Developmental considerations based on the work of Piaget are acknowledged at the middle grade and secondary curriculum level and serve as a justification for the scope of the information introduced and the way this information is presented and dealt with.

The Montessori method, on the other hand, begins with the psychological characteristics of children at this level and focuses on providing the child with a means for mental development. Rather than a consensus of learning objectives, the history-social sciences curriculum has evolved out of Maria Montessori's extensive work with children and caters to the child's developmental needs and interests. Whereas the public school curriculum specifies course work to develop an array of skills and understandings, the Montessori approach offers an educational plan for assisting students in their own self-development while helping them to foster a global view and an understanding and respect for the interdependence of life. The curriculum represents what has worked effectively over time to cultivate the child's natural desire to learn emphasizing the acquisition of knowledge through the child's own efforts rather than through the superficial covering of specified course work.

Instructional Implications

Both the public school and Montessori curriculums also vary in the way they influence the type of instruction given within the classroom. The specific course material and the numerous objectives integrated at each grade level in the public school

curriculum contributes to the necessity of using textbook based instruction within the classroom. Learning activity suggestions given in the framework are viewed as a means for supplementing and enriching the curriculum, and instruction can be interpreted as being whole group oriented. Literature is used extensively within the curriculum and the concept of history as a story well told is emphasized. The framework also stresses the importance of studying major historical events and periods in depth.

The Montessori curriculum focuses on self-initiated research projects founded on key presentations rather than textbook based group instruction. Stimulating materials, such as the time lines of early human beings, are used to motivate students to explore on their own, and the child's active involvement is seen as crucial to the learning process rather than as a means for enriching the curriculum. Imaginative stories based in fact are used to ignite the curiosity of the student and relevant literature and non-fictional information is made available for the child's use within the classroom. Whereas the volume of material to be covered at each level within the public school curriculum, particularly during the middle grades, makes the possibility for in depth studies a difficult task, the open-ended structure of the Montessori curriculum facilitates and encourages extensive explorations integrated across subject areas.

Multiculturalism

The curriculums also differ in the approach each uses to establish multiculturalism within the classroom. A multicultural perspective is introduced in the public school curriculum by examining students' backgrounds and cultural heritages in the lower grades, and by studying the many groups of immigrants who have built this state and country. A formal study of cultures different from those in the United States is not initiated until the sixth grade when the child is introduced to early humankind and ancient

world history. The framework states that the experiences of all the different cultural groups who exist in the United States are to be integrated at every grade level in the history-social sciences curriculum.

In the Montessori classroom the child explores different cultures during the early childhood years by examining how people around the world have fulfilled their common needs. At the elementary level, the student traces the evolution of early people and civilizations, and explores how environmental factors have influenced the way different groups of people have satisfied their physical and spiritual needs. Through this approach, the child is led to see that humankind has evolved from a common ancestry and that people are more alike than different. The study of culture is placed in the context of human unity, and respect for cultural diversity is fostered. The child's own heritage can be understood and appreciated within this framework and the student's role as a world citizen is validated. By the late elementary years, as the child explores the history of our own country and state, she will have already been introduced to the people who settled here and will understand their experiences in the broader context of the development of humankind. Rather than emphasizing the experiences of numerous ethnic groups within our country to cultivate a multicultural perspective, the Montessori curriculum unifies the human experience by stressing the commonalities of all people throughout the history of humanity.

Concept of Chronology

Another area of dissimilarity between the state and Montessori curriculums is the method used by each to present a sequential study of history. Despite the frameworks claim as being centered in the chronological study of history, the curriculum itself adheres to an expanding environments format, which begins with the child's family and

moves outward toward world history. In this perspective, local, state and national history are presented to the child before exploring world and ancient history so that the student is not formally introduced to the earliest periods of human life until the sixth grade. While the course work of each year may present specific events sequentially in time, e.g. U.S. history begins with an examination of pre-Columbian settlements, the years themselves are disconnected from one another and often cover material from the same period of time.

The Montessori curriculum, on the other hand, begins the study of history with the earliest known humans and chronologically progresses toward modern culture. Early settlements and civilizations are thoroughly explored before the student is introduced to her own national and state history, and geography and biology are explored in conjunction with historic periods to provide a basis for understanding trends and cause and effect relationships. By carrying the learning over from one year to the next, a consistent chronological study of history can be constructed and a framework for understanding events in time and place can be established.

Conclusion

The California history-social sciences curriculum, although recently updated, represents a modified traditional approach to the instruction of history and the social sciences. The document's emphasis on the importance of history within the social sciences and humanities and its integration of literature, interesting activities, and other subject areas into the curriculum is an improvement over traditional textbook dominated approaches to history-social science learning. Although similar to the state's curriculum in some respects, the Montessori method offers a framework for the study of history and the social sciences that caters to student's individual interests and learning abilities. The curriculum provides a means for integrating diverse subject matter within the Montessori

classroom and enables students to study history chronologically across the elementary grades rather than within individual grades. The approach is comprehensive and serves as a viable alternative to more traditional programs of history and social studies instruction.

SCIENCE CURRICULUM COMPARISON

The State Science Curriculum

California's science curriculum, described in the *Science Framework for California Public Schools, Kindergarten Through Grade Twelve*, was adopted by the state's board of education in the fall of 1989. Based on two previous frameworks issued in 1978 and 1984, the new *Science Framework* aims to achieve scientific literacy for all students and emphasizes a thematic, integrated approach to science education stressing the importance of hands-on learning. It is the intent of the framework to influence the development and selection of instructional textbooks and materials and to serve as a resource for curriculum revision and teacher education. The framework was developed by a committee of teachers, curriculum specialists, and faculty of higher education, and reflects current thinking on instructional practices in the natural sciences.

The *Science Framework* discusses the nature of science, the content of California's science curriculum from kindergarten through the twelfth grade, and strategies for achieving an effective science program. The framework's introduction identifies the following expectations for science programs within the state's schools:

1. Major themes underlying science, such as energy, evolution, patterns of change, etc., are developed and deepened through a thematic approach.
2. Physical, earth, and life sciences are ideally addressed yearly and connections among them are developed.

3. The character of science is shown to be open to inquiry and controversy and free of dogmatism; the curriculum promotes understanding of how we come to know what we know and how we test and revise our thinking.
4. Science is presented in connection with its applications in technology and its implications for society.
5. Science is presented in connection with students' own experiences and interests, frequently using hands-on experiences that are integral to the instructional sequence.
6. Students are given opportunities to construct the important ideas of science, which are then developed in depth through inquiry and investigation.
7. Instructional strategies and materials allow several levels and pathways of access so that all students can experience both challenge and success.
8. Printed materials are written in an interesting and engaging narrative style; in particular, vocabulary is used to facilitate understanding rather than as an end in itself.
9. Textbooks are not the sole source of the curriculum; everyday materials and laboratory equipment, videotapes and software, and other printed materials such as reference books provide a substantial part of student experience.
10. Assessment programs are aligned with the instructional program in both content and format; student performance and investigation play the same central role in assessment that they do in instruction.

The Nature of Science

The first chapter of the *Science Framework* explores the nature of science including the disciplines' basic principles and methods. The chapter is divided into sections beginning with an introduction stressing the importance of preparing scientifically literate citizens for making decisions about science, technology, and public policy in our democratic society and fostering an understanding of what science is and what it is not. The second section emphasizes the importance of making science education enjoyable, while the third section, entitled “Teaching What Science Is”, delineates the following four points which should be made clearly to students and integrated into science textbooks, curricula, and class discussions:

- Science has its own character as an intellectual activity and aims to be testable, objective and consistent.
- Science is open-ended, but scientists operate with expectations based on the predictions of theory.
- Science is based on observations set in a testable framework of ideas.
- Scientific inquiry is guided by theory.

The fourth section examines scientific practice and ethics and stresses the importance of doing science the right way rather than merely coming up with the right answers. A discussion on social issues in science in the fifth section emphasizes that education's goal is understanding, not belief, and that socially sensitive issues do have a place in the science classroom as long as they are treated conscientiously and from a scientific perspective.

The Major Themes of Science

The second chapter in the *Science Framework* explores six major themes of science and how these themes can be incorporated into the curriculum. The document defines themes as the big ideas, overarching concepts, unifying constructs, or underlying assumptions, which link the theoretical structures of the various scientific disciplines. They are used to integrate concepts and facts at all levels of the curriculum, and provide a context for presenting content matter. The six themes examined in the framework include: energy, evolution, patterns of change, scale and structure, stability, and systems and interactions.

The framework emphasizes that themes are necessary in the teaching of science because they are necessary in the doing of science, and that many different themes, in addition to the six developed within the framework, can be used to organize the presentation of scientific content. The chapter concludes by providing the following suggestions for how themes can be used to enhance the science curriculum:

1. Themes should be used to integrate concepts and facts at all levels of the curriculum.
2. Themes should be used to integrate the main subfields of scientific disciplines.
3. Themes in science should direct the design of classroom activities.
4. The emphasis on themes in science requires a reconsideration of how much detailed material should be included in science curricula.
5. Using themes in curricula can improve the quality of prose.
6. Assessment should be thematically based.

7. Themes can be used to lay out basic principles of science that will operate in many subfields and other disciplines of science.

The Content of Science

The third, fourth, and fifth chapters of the *Science Framework* illustrate one way that a conceptual approach to the teaching of science might be organized. Structured around the traditional content areas of science (physical, earth and life sciences), the framework summarizes the major theories in each discipline and follows each summary with a set of questions central to that theory. The questions are then answered in narrative form written from the perspective of one or more of the major themes developed in the framework according to grade level groupings. Rather than identifying content by specific grade level, the framework has grouped the narrative replies according to what content should be introduced from kindergarten through grade 3, grades 3 through 6, grades 6 through 9, and grades 9 through 12.

The model curriculum presented in the *Science Framework* is meant to be illustrative and is not intended to be used as a checklist of what facts and information must be introduced at each level. However, concepts presented at one level should not be introduced at an earlier or later grade level. The following outline highlights the subject areas covered in the framework's sample curriculum, which are first introduced in a simplistic manner at the lower elementary level and later revisited at each subsequent level in more depth and detail.

Physical Sciences

Matter

Reactions and Interactions

Force & Motion

Energy: Sources & Transformations

Energy: Heat

Energy: Electricity & Magnetism

Energy: Light

Energy: Sound

Earth Sciences

Astronomy

Geology & Natural Resources

Oceanography

Meteorology

Life Sciences

Living Things

Cells, Genetics, & Evolution

Ecosystems

Achieving the Desired Science Curriculum

The final three chapters in the *Science Framework* provide information on how to achieve the desired science curriculum. Chapter six, entitled "Science Processes and the Teaching of Science", begins with a section emphasizing the importance of centering instruction on the same fundamental processes used by scientists in their everyday work. The section discusses the scientific processes of observing, communicating, comparing, ordering, categorizing, relating, inferring, and applying, and provides a list of statements and questions which could be used by a teacher to facilitate the student's experience with each process. For example,

to facilitate the process of comparing, the teacher could ask, “How are these alike?”, “How are these different?”.

The chapter's second section explores the scientific processes in the context of child development. The document acknowledges that all the processes of science can be used to some extent at all ages, but notes that certain processes contribute more to learning during specific developmental stages than during others. The framework identifies the processes of observing, communicating, comparing, ordering, and categorizing as valuable from kindergarten through the third grade, and recommends emphasizing the development of descriptive language in all areas of the natural sciences through the use of these thinking processes. At the third through sixth grade level the framework suggests developing the process of relating in addition to those already introduced, and recommends providing opportunities for making inferences at the sixth through ninth grade level.

The third section of chapter six focuses on ways to help students develop science concepts based on the assumption that new knowledge is built on the ideas that the student already possesses. To help teachers promote the learning of new concepts the framework offers the following recommendations:

1. Pose questions to determine what ideas students hold about a topic before beginning instruction.
2. Be sensitive to and capitalize on students' conceptions about science.
3. Employ a variety of instructional techniques (small-group work, direct-learning activities, etc.) to help students achieve conceptual understanding.
4. Include all students in discussions and cooperative learning situations.

The role of direct experience in science education is examined in the fourth section of chapter six. In addition to citing why hands-on investigations are essential for true understanding, the framework stresses the importance of engaging students in activities they care about and where they are placed in a position of responsibility for the learning task. This can be achieved by engaging students in tasks in which they have control of the learning episode and are able to manipulate at least some aspect of the activity.

The importance of incorporating ethics and such scientific values as curiosity, open-mindedness, objectivity, and skepticism in science education is discussed in the fifth section of chapter six, while the sixth section explores the need to utilize a science, technology, and society approach when teaching science. The framework encourages science teachers to demonstrate how science operates in the United States and elsewhere, to examine job prospects and interest areas within the science and technology arena, and to describe how the products of science and technology change society.

In the seventh and eighth sections of chapter six, the framework presents guidelines for implementing programs at the elementary and middle school levels. At the **elementary level**, a science program, as far as possible, must:

1. Provide a balanced curriculum in the physical, earth, and life sciences.
2. Show students that science is enjoyable.
3. Reinforce conceptual understanding rather than rote learning.
4. Organize an articulate scope and sequence at the school level.
5. Arrange the classroom setting and student grouping to optimize positive attitudes for learning science.

6. Integrate science with other subjects.
7. Make full use of community resources.

At the **middle school level** (traditionally grades six through eight) the science program, as far as possible, must:

1. Introduce students to the connections among the disciplines of the physical, earth, and life sciences.
2. Expand the role of the science processes.
3. Motivate students to take and learn more science.
4. Create long-term projects with students.
5. Make full use of community resources.
6. Establish the relevance of science lessons outside the school context.

The chapter concludes by recommending ways that teachers can encourage the historically underrepresented (females, minority groups, and persons with disabilities) in the natural sciences and how science teachers can instruct limited-English-proficient students.

Implementing a Strong Science Program

The seventh chapter of the *Science Framework* deals with the implementation of a strong science program. The document suggests that a wide range of people, including administrators, school faculty, parents, district and county personnel, and local college and university representatives, participate throughout the implementation process and acknowledges that a well-formulated district wide plan for science education provides the basic design for the establishment of an effective science program. The importance of adequate

teacher preparation is noted as well as the need to fashion assessment programs that consider the nature of the instruction itself. Resources and teaching technologies are discussed and the framework predicts that the role of the teacher will most likely evolve from disseminator of information to a facilitator of students' learning through the increased use of technology within the classroom. An implementation model is also included in the chapter as well as a discussion of how the framework's proposed curriculum relates to the other curriculum plans adopted by the California State Board of Education. Within this section the authors acknowledge that the changes reflected in the *Science Framework* are part of an overall reform strategy to transform education so that it cultivates higher-order thinking and reasoning in all subject areas.

Instructional Material Criteria

Chapter eight of the *Science Framework* establishes criteria for the adoption of science instructional materials based on the philosophy and guidelines presented in the previous chapters of the framework. The content of the material, the way it is presented and the pedagogy, or instructional methods, that is employed, are all areas taken into consideration during the adoption process by the State Board of Education. The outline provided below summarizes the criteria used in the adoption of science instructional materials from kindergarten through the eighth grade in the state of California:

A. Content

1. The topics discussed in the content section of this framework are treated in the instructional materials under consideration.
2. Content is treated accurately and correctly.

3. Instructional programs should be organized around themes, not around facts.
4. Instructional materials should emphasize depth of understanding, not encyclopedic breadth of coverage.
5. Explanations should embroider the accumulation of knowledge, with a detailed description of how it is that we come to know these facts and why this information is important.

B. Presentation

1. Language must be made accessible to students.
2. The prose style of instructional materials should be considerate and engaging, and the language and vocabulary of science should be respected.
3. The character of science must be represented faithfully; it must be shown as open to inquiry, open to controversy and nondogmatic by its nature.
4. Science should not be presented as an enterprise operating in isolation from society and technology or from other fields of knowledge.

C. Pedagogy

1. Instructional programs must be connected with experience.
2. Instructional materials must recognize cultural diversity and reflect strategies that research and practice have shown to be successful in meeting the needs of all students.
3. Assessment should be integrative and oriented toward solving problems, not simply recall-based.

The Montessori Science Curriculum

The sciences introduced in the elementary Montessori classroom are an important component of cosmic education and cater to the radical changes the child goes through at this level. No longer content with sensorial experiences, the elementary child's interests extend beyond the immediate environment and the student becomes concerned with understanding the reasons of things. To satisfy the child's curiosity to know and to answer her questions of where, when, how, and why, a picture of the whole--one of the earth as it is set in the universe--is presented to the child. All aspects of the earth's creation are explored as well as the importance of plants and animals in preserving the balance of our planet. By proceeding from the whole to specific details, the child is led to better understand the relation of one part to another and from each part to the whole. The interconnectedness of our world is emphasized, and the child is presented with information enabling her to understand the world in which she lives.

Earth, life, and physical sciences are explored in two Montessori curriculum areas; geography and biology. Geography examines the story of the earth and focuses on how the earth came to be; the function of the sun, air, and water; and the contributions of plants and animals in preserving the planet's balance. Biology is viewed as an aspect of the creation of the earth and explores the needs of plants and animals, ecology, and classification. Lessons in both curriculum areas are given to small groups of children, and incorporate factual information as well as myths and fairy tales symbolizing the truths of nature in order to strike the child's imagination and arouse her interest. Illustrative charts, demonstrations, and experiments are also used during presentations to make an impression on the

child and to help her visualize how the world functions. The child then has the possibility to explore topics of interest on her own or may repeat the experiments herself using written instructions referred to as command cards. The command cards help the child to organize her thoughts clearly and sequentially, and provide the student with a format for making up and writing her own experiments. Accurate scientific terminology is used within the presentations in both curriculum areas and is linked to its etymology where possible to help the child make sense of the language. Nomenclature booklets in the elementary classroom serve as a reference and as a source from which terms that facilitate understanding of scientific concepts can be memorized.

The Montessori child's preparation for elementary science begins in the early childhood classroom. The cultural subjects, described in the history-social science curriculum comparison in this paper, introduce the student to basic geography and biology concepts, and provide a foundation for the study of both at the elementary level.

The Montessori Geography Curriculum

The Montessori elementary geography curriculum can be divided into six broad units of study: The Creation of the Earth, Nature of the Elements, The Sun and Earth, The Work of Air, The Work of Water, and Economic Geography. Each unit serves as a follow-up to the story of the earth's creation and should be presented as details set in the framework of the whole rather than as facts to be learned and memorized. The units are closely related and may be presented according to the interests of the students once the story of the earth's formation

has been given. How the material is organized throughout the elementary years will differ depending on the teacher or school.

Creation of the Earth

The story of the earth's creation is presented to the entire class early in the school year and serves as the new elementary child's introduction to both the study of science and history. The entire story is given at one seating and can be based on a printed story given to Montessori teachers during their training or developed by the teacher himself. Fairy tales symbolizing facts are used within the story to catch the student's interest, and emphasis is placed on the idea that laws effecting all particles have achieved order within our universe. A number of large, impressionistic charts are displayed during the story to help the child visualize phenomena, such as the relative size of the earth to the sun, and seven different experiments representing basic laws of nature are demonstrated during the presentation. For example, to illustrate that matter settles according to its weight, water, oil, and mercury are poured into a test tube and observed as they form three distinct layers. Books about the solar system and the universe should be made available in the classroom following the presentation, and portions of the story can be retold in more detail if students express an interest in hearing it again. Various follow-up activities, such as swinging a bucket of water over our heads to demonstrate why we don't fall off the earth, can be presented before specific details about the earth are explored more formally.

The unit's remaining lessons examine the composition of the earth. The earth's spheres, the concept of gravity, the layers of the earth, and various pressures influencing the surface of our planet are sequentially explored through

the use of charts, demonstrations, and materials allowing students to investigate attributes of our earth on their own. A series of presentations on mountain building may also be included in this chapter, but is more technical and would probably not be introduced until students were older.

Nature of the Elements

In this unit, basic principles of nature are explored through factual lessons that use personification and imagery to engage the student's interest and assist her understanding. For example, in one presentation particles are said to be "very stubborn in solids" and "more obliging in liquids " in an attempt to describe the phenomena in terms that the student can relate to. Teacher demonstrations, such as melting wax to illustrate particles becoming loose when heated, are used to illustrate basic laws of nature, and students are encouraged to repeat the experiments themselves using corresponding command cards. The lessons serve as a means for organizing the information and only as much as well will make an impression on the child should be presented at one time. The main topics and subtopics examined in this unit include:

A. The Three States of Matter

B. Further States of Matter

Solids: Rigid, Elastic and Plastic

Liquids: Fluid and Viscous

Solids Can Have Elasticity

C. Different Ways of Combining

Solutions

Noncombining Particles

Mixing Particles

Precipitated Reactions

Chemical Reactions

Saturation

D. Attraction and Gravity

Magnetic Pull

Heaviest Particles Settle Towards the Center

Gravity

Heavy Objects Sink

The Sun and Earth

The Sun and Earth unit in the Montessori geography curriculum explores how the sun influences the earth. The unit consists of four lessons and includes presentations on four different work charts that are manipulated in some manner by the student to reinforce particular concepts introduced during the lessons.

The first lesson, referred to as "The Rotation of the Earth and its Consequences", uses a globe, a lamp, and a number of charts to illustrate how the earth is effected by its own rotation and by its rotation around the sun. The lesson explores why we have night and day, and examines how the earth is heated and cooled in a 24-hour period. Follow-up activities include an introduction to AM and PM and to longitude and latitude.

A second lesson in the unit explores the influence of the sun's perpendicular and oblique rays on the earth. Toothpicks are placed in both a flattened piece of clay and a spherical ball of clay to demonstrate how the curve of our planet's surface causes the sun's rays to fall obliquely on specific areas of the earth. A

flashlight is then shone on a piece of paper both perpendicularly and obliquely to show how the perpendicular rays are more intense. The lesson continues by discussing why it is warmer at the equator than at the poles using a variety of charts to illustrate the different explanations.

The next lesson presented in this unit, entitled "The Seasons", explores how the earth's tilt influences the length of our days and the different seasons we have within our year. A story intended to excite the student's curiosity is used to introduce the idea that our days change in length during the year. A clay sphere on a pointer stick is then rotated around a lamp in a tilted position to demonstrate how the sun's perpendicular rays hit the earth at different points during the earth's rotation around the sun causing some areas to get more sun at certain times of the year than other areas. A connection between the length of day and the season is made during the lesson and the student is introduced to the terms solstice and equinox. Follow-up exercises further explore the effects of the planet's tilt through the use of factual charts. Four work charts (a work chart of zones, a time zone chart, a protractor zone chart, and a work chart for the seasons) are introduced at this point to reinforce ideas presented in the seasons lesson.

The last lesson presented in the Sun and Earth unit examines our atmosphere and how rain occurs. Impressionistic charts are used to show how our atmosphere absorbs radiated heat and simple experiments, such as placing a cold lid over a pot of boiling water so that the moisture turns back into liquid, help the child to understand why it rains. Extensions to this lesson are open-ended and could include a study of cloud formations, precipitation, the geography of deserts, etc.

The Work of Air

The Work of Air unit focuses on the planet's winds and how these have influenced our earth's climate. The unit begins with a demonstration of three experiments showing that air occupies space, rises when heated, and moves to replace heat that has risen. Six lessons are presented in the unit using a combination of charts, demonstrations, and experiments, and three of the charts introduced are also used as work charts through the addition of a moveable sun and some arrows. Topics and subtopics explored in this unit include:

A. The Winds

Simple Cycle of Winds

Introduction to Pressure Zones

Slanted Movement of Winds

Steady and Variable Winds

B. The Effects of Heat on Land and Water

Absorption of Heat by Land and Water

Sea and Land Breezes

C. Seasonal Changes

Perpendicular Rays of the Sun

Effects on Wind Directions

Effects on Rain

D. Local Winds

E. The Oceanic Currents

The Winds Effect on Currents

Vertical Motion of Currents

F. Erosion By Wind

The Work of Water

Six lessons examining how water in its various forms has helped to shape the surface of our planet are presented within the Work of Water unit. Clay models representing land formations are used in many of the lessons to demonstrate how rivers, rain, and waves have altered the earth's exterior, while both factual and impressionistic charts are used throughout the unit to illustrate the concepts being introduced. Students should be taken to places in nature showing the phenomena introduced when possible, and can follow-up the lessons by building their own models. The unit's topics and subtopics include:

A. Work of Rivers

- Carving a River
- River Deposits
- Introduction to Highlands and Lowlands
- Rivers of North America
- Rivers of the World
- Introduction to Cities on Rivers
- 'V' Valleys and Canyons

B. Work of Rain

C. Work of Waves

D. Work of Ice

- Breaking Rock Apart
- Glaciers
- Results of Glaciers

E. The Cycle of Water

The Montessori Biology Curriculum

The subject of biology in the Montessori classroom is closely related to the child's history work and focuses on the immense variety of ways plants and animals have fulfilled their needs. Biology is viewed as an essential factor in the story of the earth's creation, and the curriculum's main concern is to foster an appreciation for the diversity of life and to instill an awareness of the importance of preserving the balance of our planet.

The Montessori biology curriculum is divided into four areas (botany, zoology, classification and ecology) and caters to the elementary child's ability to reason and her desire to know the how and why of things. Lessons incorporating allegory and personification are used to arouse the child's curiosity, and charts and experiments are used within the talks to engage the child and to help clarify the information presented. Observations of plants and animals both in the classroom and nature are an important part of the biology work, and relevant books should be made available to children within the classroom. Either botany or zoology can be given first, or both may be explored simultaneously. Classification activities may be started once the child has attained a store of information about the variety of features in plants and animals.

Botany

The botany portion of the Montessori biology curriculum begins by introducing the primary needs of plants through three experiments. During the first experiment seedlings are placed under different conditions to emphasize that

plants need water, light, and heat in order to grow. The second experiment demonstrates that plants have a tendency to grow toward the sunlight, while the third exercise shows that plants need a variety of minerals for optimal health. A chart illustrating the needs of plants can be presented to summarize the experiments and to interest the child in how plants function.

Each part of the plant, which includes the leaves, roots, stem, flower, fruit, and seeds, are then individually explored through a series of lessons incorporating experiments, demonstrations, and charts. The first lesson presented for each part examines the function or contribution that part makes to the plant and frequently uses a story format. Subsequent lessons investigate the plant part in more detail and how different varieties of the part have assisted plants in adapting to their environments. The main lessons included in this unit are as follows:

A. Leaves

Function of Leaves

Plants Give Out Oxygen

Parts of Leaves

Varieties of Leaves

Varieties According to Function

B. Roots

Experiments Showing Roots' Attraction to Water

Roots Absorb Water

Other Functions of the Root

Two Main Types of Roots

Other Sensitivities of the Root

Varieties of Roots

C. Stems

General Function of Stems

Two Main Kinds of Stems

Names of Tubes

How Water is Moved Up the Stem

Varieties of Stems

D. Flowers

Introductory Story to the Flower

Parts of the Flower

Varieties of Flowers

Specialization to Assure Pollination

E. Fruits

Main Function of Fruits

Kinds of Fruits

Parts of Succulent Fruits

Other Varieties of Fruits

F. Seeds

Kinds of Seeds

Function and Parts of Seeds

Seed Dispersal

Accurate scientific terms are given throughout the presentations and botany card material, consisting of picture, name, and definition cards for botany concepts, can be introduced to help familiarize children with the terms and their

definitions. Command cards providing directions for repeating the experiments demonstrated in the presentations can also be made available to students.

Zoology

The zoology component of the Montessori biology curriculum focuses on the needs of animals and how these needs explain the animal's features and behaviors. Animals kept in the environment help students to become aware of the special needs animals have and provide opportunities for detailed and systematic observations. Two sets of materials, the story material and the body function material, are used in the classroom to help guide the child's explorations and to introduce different ways for classifying animals.

The story material consists of a set of envelopes each dealing with a different animal and containing a picture of the animal, a card of text, picture cards showing how the animal meets her needs and text cards relating to these. Various exercises using the materials are presented to small groups of children to help them become aware that all animals have the same needs but that they satisfy these needs in different ways. Question and answer cards pertaining to how the animal meets her needs, e.g. How do they move? (walk, crawl, swim, etc.), are then introduced as a simple means for classifying the animals and to start the children thinking about the immense variety of animals that exist.

The body function material, consisting of booklets, picture cards, and definition cards, are used to synthesize the knowledge the student already has about animals and to introduce the five classes of vertebrate. Various matching exercises provide the child with opportunities for exploring both the external and

internal functions that define a group or class of vertebrate and prepare the child for working with the animal classification material.

Classification

The Montessori plant and animal classification material enables students to develop their analytical abilities by providing them with opportunities to decide whether to place a specimen in one particular group or another. The material, which is composed of picture cards, text cards, and circular cards indicating the level of the subdivision it represents, is organized into envelopes by group with each envelope varying in size in such a way that subdivisions can fit inside of it. Children are introduced to the subdivisions of classification by either working down from each of the kingdoms or by working up to the kingdom beginning with a particular subdivision. Various activities allow children to become familiar with the characteristics for different subgroups and prepare the child for creating a tree of classification which progresses from kingdom to families using the classification circle cards and cardboard branches corresponding to the number of groups being laid out. Students are also shown how to use books to trace a plant or animal's genealogy.

Ecology

The study of ecology in the Montessori elementary classroom focuses on viewing the world as an ecosystem and on the delicate balance existing between organisms and the environment. The idea of interrelatedness is emphasized and is introduced by exploring the physical and biological factors existing in our world and how these factors relate to one another within various ecosystems on our planet. Ecology serves as a natural conclusion to the child's work in many areas

of the Montessori curriculum and can be explored in a variety of ways depending on the student's interests.

The State and Montessori Science Curriculums Compared

The ideas and strategies presented in the *Science Framework for California Public Schools* are meant to be used as guidelines for the development and adoption of materials for science education from kindergarten through twelfth grade. The document emphasizes ways to improve science education in the state and provides an overview of how science works and how the processes and methods of science can be used to structure effective instructional programs. Although the *Science Framework* does specify what content should be presented and how this might be organized, it is not the intent of the document to describe specific activities, procedures, or materials to be used in science education within the classroom.

The Montessori science curriculum, on the other hand, provides detailed descriptions of actual lessons and materials presented within the early childhood and elementary classroom, and it serves as an open-ended plan for introducing scientific concepts to children based on their developmental needs. Whereas the state framework establishes criteria for science education, the Montessori science curriculum is itself an instructional program and describes presentations and techniques for stimulating the student's interest in science. Despite different purposes and formats, the basic approach to science education advocated by the state of California is similar in many ways to the approach developed in the Montessori method.

Similarities

The importance of organizing content thematically is recognized by the state and the Montessori approach, and both provide for a balanced curriculum in the physical, earth, and life sciences. Educational activities related to the student's own experiences and interests are viewed as essential to the learning of science by each curriculum and both emphasize conceptual understanding rather than rote learning and the memorization of disconnected facts. The elaboration of concepts and ideas when revisited at higher levels is recommended by both approaches and the state's recognition that repeating classical experiments can be beneficial to a child's understanding of science supports the Montessori practice of allowing children to repeat on their own the numerous experiments demonstrated during class presentations. Although the curriculums may differ as to when specific content could be introduced, many of the topics included in the state's recommendation for science education from kindergarten through sixth grade are also introduced within the Montessori plan for elementary science.

The *Science Framework's* requirement that instruction should involve students in meaningful activities emphasizing problem solving and decision-making resembles the Montessori view that children should be free to answer their own questions and that learning should result from personal interest and involvement in self-chosen work. The importance of arranging the classroom setting to encourage curiosity in science is emphasized in both curriculums and each advocates allowing students to explore and discover ideas for themselves. Both approaches recognize the importance of questioning students to bring about greater awareness of scientific concepts and view the teacher's enthusiasm and ability to interest and motivate students as crucial in the teaching of science. Each

curriculum also recognizes the value of integrating the natural sciences with other subject areas in the classroom.

The public school requirement that science programs incorporate a variety of instructional materials to actively engage children in doing and learning about science is in keeping with the Montessori method's use of diverse materials and resources to stimulate the student and encourage self-directed activity. The importance of allowing for long term instructional units and in-depth investigations is recognized by each curriculum as is the immense potential of the community as a resource in science education. The *Framework's* emphasis on incorporating a lively and engaging narrative style in written material to interest students is similar to the Montessori curriculum's use of fascinating stories in verbal presentations to inspire children and encourage scientific research. Both approaches also stress the importance of using appropriate vocabulary to facilitate understanding and linking science with technology in the classroom.

Differences

Despite the many theoretical similarities between the two approaches, some differences between the curriculums become apparent when the recommendations made by the framework for implementing the state's guidelines in science education are compared to practices carried out in the Montessori approach. The curriculums differ as to: (a) what specific content is included, (b) when material is presented, and (c) how the concepts and ideas necessary for an understanding of science are introduced.

Content Specifications

One area of difference between the *Science Framework* and the Montessori approach is in what content is specifically included in each curriculum and to what extent. The state requires that topics discussed in the framework, those representing the traditional content areas of science, need to be included in instructional material, and that weight should be given to the terms and concepts that support and develop the basic ideas of a field. Narrative explanations in expository materials should include detailed discussions of topics focusing on how we have come to know scientific information and why this knowledge is important, and should emphasize depth rather than breadth of coverage. The content included must be accurate and represent what is currently known of science and the quality of the presentation--how well topics are treated and integrated with other concepts and ideas in instructional materials--is a more important criterion than the number of topics introduced.

Although most of the concepts and ideas presented in the Montessori plan for science education are included at some level in the state curriculum, many topics introduced in the *Science Framework* are not specifically included in the Montessori curriculum. Only key concepts and relationships that provide a basis for understanding the different areas of science are presented in the prepared Montessori curriculum while other topics, such as energy, motion, and anatomy, are not specifically included but can later be taken up for study according to the interests of the students themselves. Detailed discussions of topics and mandatory reading assignments are not a part of the prescribed Montessori curriculum, which favors instead leaving children free to explore and research on their own using a variety of materials. The use of numerous resources, rather than a single

textbook, provides opportunities to examine topics from different perspectives and helps to ensure that information pertaining to what is currently known of science can be consistently brought into the environment. The quality of the presentation of key concepts and ideas is emphasized in the Montessori curriculum and only selected information that provides a foundation in the earth, life, and physical sciences is introduced to motivate children to explore and learn through their own activity.

When Content is Presented

Another area of dissimilarity between the state's plan for science education and the Montessori approach is at what age level different categories of content are presented within the two curriculums. Content included at the kindergarten through third grade level in the framework is factually based and is meant to help students build a mental picture of the world. At the third through sixth grade level content focuses on the principles and laws of science. At the sixth through ninth grade level the curriculum explores scientific ideas that are not directly observable. This progression reflects an expanding horizons format frequently applied in the teaching of history-social sciences and assumes that children should not be introduced to abstract concepts until cognitively able to comprehend ideas not represented by concrete objects or materials. Thus, in the study of earth science, students in the elementary years explore what is in the universe (what is observable) but are not introduced to its history, including the "big bang" theory of its beginning, until the middle school level. Content is distributed by grade level groupings in the public school's science curriculum and emphasis is placed

on introducing component units of a program in the order given so that later concepts can build on those already presented.

Montessori science education, on the other hand, introduces factual knowledge about the world at the early childhood and kindergarten level while children are particularly interested in such information and begins to explore the laws and basic principles of nature through a systematic study of the universe early in the elementary years. Rather than waiting until the middle school period to explore the creation of the universe, this information is presented in a fascinating story to the early elementary student to arouse curiosity about the world and to help the child establish a framework for examining nature and scientific phenomena. Impressionistic materials, which stimulate the child's imagination and reasoning mind, are used to explore time and space beyond the limits of the classroom. The child's own needs and interests, not a preestablished syllabus, determine when content is introduced and what specifically is taken up for research. While the lessons within a unit of study in the Montessori curriculum would generally be introduced in order, the units themselves need not be presented in a particular sequence and may be picked up and set aside according to the interests of the student. Topics explored at an early age that are beyond the conceptual understanding of the child can be reexamined with more clarity and depth at a higher level thus eliminating the need to restrict or predetermine when specific content should be introduced.

How Content is Presented

The state requirements and the Montessori method also differ in how the concepts and ideas necessary for an understanding of natural science are introduced and treated. In an attempt to avoid an emphasis on isolated facts and definitions that have long dominated science instruction, the framework repeatedly stresses the importance of integrating factual information along thematic lines in both the presentation and teaching of scientific content. Printed expository materials used in science education need to present in-depth discussions of topics and ideas and should be organized around themes to connect facts and concepts across the different scientific disciplines. Thematically based instruction needs to reflect successful practices and children should be involved in hands-on activities 40% of the time. The fundamental processes of science--observing, comparing, ordering, etc.--as well as problem solving and decision making should form the basis for classroom activities, and both printed materials and direct learning should be related to real experiences. The integration of facts and concepts thematically is viewed as a means for promoting an understanding of ideas, rather than the memorization of facts, and is intended to improve both the quality of prose in expository materials and the instructional methods used within the classroom.

Where the state curriculum emphasizes the integration of facts and ideas throughout the teaching of science, the Montessori approach both interconnects and isolates concepts depending on a particular lesson's purpose. During the *Creation of the Universe* story, factual information is integrated in order to excite the interest of the child and to provide an overview for the study of basic scientific principles. Once the student has been given the "big picture", concrete

materials are used to introduce key concepts in isolation before the child is expected to connect ideas into more complex relationships. The amount of factual information presented is purposefully limited to encourage exploration and understanding through the child's own activity, and the use of numerous resources, rather than a single textbook, enables the child to discover for herself the many ways facts and ideas may be connected. Student follow-up activities may not only lead children into problem solving, decision making, and using the fundamental processes, but may also involve them in extensive reading, report writing, recreating experiments, or designing their own investigations. Units of study or consecutive chapters within a unit may be taken up according to the interests of the child, rather than in a linear fashion, and activities become real experiences by being initiated and carried out by the child herself. Unlike the state curriculum, where the integration of facts and ideas along thematic lines permeates the teaching of science, the thematic approach used in Montessori education generally does not interconnect factual and conceptual information unless concepts have been presented in isolation first.

Conclusion

California's activity-based integrated science curriculum is a vast improvement over traditional teacher-directed programs that focus on skill attainment and rote learning. However, the curriculum's sequential teaching of content by grade level and emphasis on depth of coverage within instructional materials could limit the extent to which students pursue their own interests and are able to relate science to their own experiences. In contrast, the Montessori approach to science education establishes a framework for scientific exploration

and encourages self-chosen work in areas of great interest to the student. The Montessori curriculum, like the state's approach, seeks to develop the student's scientific reasoning and conceptual understanding, but does so in a non-linear fashion that accommodates different learning styles and various levels of ability. The Montessori method of science education is closely aligned with modern learning theory and could significantly improve the quality of science instruction in the state.

MATHEMATICS CURRICULUM COMPARISON

The State Mathematics Curriculum

The *Mathematics Framework for California Public Schools, Kindergarten through Grade Twelve*, published in 1992, builds on its predecessor, the 1985 *Mathematics Framework*, and establishes curriculum recommendations for mathematics education within the state today. The document supports extensive reform in mathematics education, reflecting the standards formulated by the National Council of Teachers of Mathematics (NCTM), and emphasizes developing the mathematical potential of all students in our public schools. Written by a committee of eminent California mathematics educators and mathematicians, it is the intent of the framework to encourage the development of new instructional materials and programs that stress problem solving and highly interactive learning experiences rather than mechanics and procedures. The framework discusses the curriculum's goals, explains how to develop mathematical power in the classroom, and describes the structure and content for mathematics education at the kindergarten through eighth grade level and from grades nine through twelve.

The *Mathematics Framework's* introduction stresses the importance of reform in mathematics education and summarizes aspects of the document that differ from the 1985 edition. The goal of mathematical power for all students, which involves the ability to discern mathematical relationships, reason logically, and use mathematic techniques effectively, is maintained in the 1992 *Mathematics Framework* with emphasis placed on providing every student in California fair access to mathematics education. The framework stresses providing teachers with the time necessary for implementing change,

and notes that involving students, their parents, and the community, as well as teachers, in reform can be beneficial to both the process and the outcome.

Mathematical Power

The first chapter in the *Mathematics Framework*, entitled "Mathematical Power", begins by discussing the long-term goals of mathematics education. A primary goal of the curriculum is that all students should be expected to cope successfully with the often complex mathematics they will encounter outside of the classroom--particularly the mathematics required for the exercise of competent citizenship in a democracy. Another goal is that students will appreciate the beauty and fascination of mathematics and approach the mathematics they will encounter throughout their lives with curiosity, enjoyment, and confidence.

To prepare students to make sense of real mathematical situations, the framework recommends introducing assignments that go beyond preorganized exercises and problems. Investigations, which serve as culminating activities and help students to integrate what they have learned, involve students in formulating problems themselves and presenting upon completion an analysis and conclusion of their work rather than a solution. Collaborative work is encouraged and one investigation may take an extended period of time to complete. Computational techniques are still introduced, but in a larger, more purposeful context.

The four dimensions of mathematical power necessary for completing investigations-- thinking, communication, drawing on ideas, and using mathematical tools and techniques-- are examined in the chapter's next section as well as four goals that support mathematical power. These include: (a) facility with the four dimensions of mathematical power, (b) working successfully both individually and with others, (c)

coming to appreciate mathematics in history and society, and (d) exhibiting a positive attitude toward mathematics. To enable students to demonstrate mathematical power in their work, the program must:

1. Foster a common expectation of quality work.
2. Prepare students for complete work.
3. Give students the time and tools they need to do that work.
4. Require that the mathematical work be done according to a comprehensive standard.
5. Help students develop a habit of draft, feedback, and revision.
6. Provide tasks worthy of quality large-scale work.

The *Mathematics Framework* recommends using a rubric as the standard against which the work is judged in order to establish criteria for evaluating large, open-ended pieces of student work. A common understanding of the purpose of the work and what is to be accomplished must be shared by both the student and evaluator and should be described in terms of the four dimensions of mathematical power. The rubric is defined by different levels of performance, such as what is required for work that is considered well done, acceptable, as needing revision, or should be started over, and can be created cooperatively by a teacher and her students.

The chapter concludes by examining how children learn mathematics. Research in child development and learning suggests that children excel at higher-order thinking and actively create their own understanding of the world. Mathematical concepts are constructed by students as a means for making sense of their experiences and become more powerful when used to achieve a purpose. Connecting mathematics with the student's life outside of the school and providing many opportunities for communicating

mathematically helps children in their development of mathematical understanding. Ample time for reflecting and revising also increases the child's likelihood of mathematical success.

Developing Mathematical Power

Chapter two in the *Mathematics Framework*, entitled "Developing Mathematical Power in the Classroom", focuses on the development of mathematical competence from the perspective of the individual student. The document describes a program as the physical and written materials, the pedagogical environment, and the overarching philosophy that supports the teachers and students, and proposes that empowering mathematics programs integrate the following essential characteristics:

1. All students participate fully.
2. Students take responsibility for their learning; they question, create, and help decide what to do.
3. Teachers are facilitators of learning rather than imparters of information.
4. All students regularly use manipulatives, calculators, and computers.
5. All students frequently work together, sharing and discussing ideas.
6. All students frequently reflect their thinking orally and in writing.
7. Assessment is integrated with instruction; it focuses on what students understand and can do rather than on what they don't know or can't do.
8. The program is appropriate to the maturity and development of the student as it meets its other goals.
9. The program develops every student's positive disposition toward mathematics in several ways.

10. The program usually introduces computational procedures only when students need them.

The chapter then looks at the diversity of California's school population and the importance of removing stereotypes related to gender, race, class, or culture in mathematics education. Language-minority students should be given the opportunity to do mathematics in their primary language and mathematics programs should incorporate interconnected, worthwhile tasks that develop a sense of purpose and are accessible to a broad range of students.

The role of the teacher in empowering mathematics programs is explored in the chapter's next section. The teacher is viewed by the *Mathematics Framework* as facilitating and supporting student learning by establishing a classroom environment in which students take responsibility for understanding, doing quality work, managing their own time, and communicating with others. Teachers are responsible for framing questions, planning work that excites curiosity, and encouraging students to develop persistence in problem solving. In addition, teachers are to assume the role of practicing mathematician, modeling the behaviors and positive disposition towards mathematics that we want to develop in our students.

Classrooms should be student-oriented and nonauthoritarian and a variety of resources, including calculators, computers and manipulative materials, must be made available for student use. Students must discover their own mistakes and view these as a natural part of the learning process and be given the opportunity to develop and deepen their understanding of mathematical ideas over time. Teachers should try to provide activities that have the potential for being understood at many different levels and not expect all students to get the same thing out of the same experience.

Chapter two then considers the role of procedures, manipulatives, and technology in mathematics education. Mathematics programs should still require that students know basic facts, learn computational procedures, and determine which operations and manipulations will be most efficient in a given situation. Students should be able to calculate accurately using the best aid for the task, such as a calculator or pencil and paper, and assess whether their answers are reasonable. Students can invent ways to perform a calculation or be introduced to a computational procedure at a point when they can see why it is useful. Different approaches for obtaining the same results can be compared by students who must understand why the approach they choose makes sense for the problem they are solving.

The *Mathematics Framework* stresses the importance of using both technology and manipulatives in the classroom to help students make sense of mathematic concepts. Concrete materials and situations provide students with an experiential basis for developing more abstract concepts and serve as a focus of discussion in group activities. Calculators and computers should be made available at all times and learner-centered software, rather than drill and practice, should be used to stimulate problem solving, exploration, and self-discovery. Students should be able to choose the tools they need and when to use them.

Student groupings and assessment are also explored in the second chapter. Heterogeneous groupings of students are a goal of the *Mathematics Framework* while tracking students by ability is strongly discouraged. Students with similar interests and needs can be broken into temporary groups as long as supplemental instruction does not pull students out of the core curriculum. The curriculum should include instruction on how to work collaboratively, and mathematically gifted students should be encouraged to explore more deeply and in areas of related interest rather than working ahead of their

classmates. Quality and originality of work, rather than speed and accuracy, should be emphasized.

Student assessment, according to the framework, should be integrated with normal instruction and be based on the work students complete in class. Students participate in the assessment process themselves by establishing standards for quality work, and are helped to evaluate their own work rather than relying on the judgment of others. Three formats for assessing student work--open-ended tasks, observations of students at work, and student portfolios--are recommended by the framework, and students are expected to revise their work as necessary to meet the standards of each assignment. The use of letter grades is discouraged favoring instead oral or written descriptions of a student's mathematical work and the progress they've shown.

Mathematical Content Organization

Chapter three of the *Mathematics Framework* examines the structure and content of the mathematics program. The mathematical content proposed by the state builds on the standards for school mathematics established by the NCTM and is described in terms of strands and unifying ideas. Strands, which help to broaden the scope of a mathematics program, consist of the traditional subject categories of mathematics. They are meant to be integrated with one another and should appear in some appropriate form at each grade level. The framework stipulates that the following strands be incorporated in California's mathematics programs:

Functions

Algebra

Geometry

Statistics and Probability

Discrete Mathematics**Measurement****Number****Logic and Language**

Unifying ideas are major mathematical themes that occur in several different strands and connect individual subjects. They reveal general principles that cut across a number of strands and are too general and abstract to be the focus of a study themselves. In order to instill an in-depth understanding of these larger ideas, they are introduced in many different contexts over the years but should receive emphasis at the grade level when newly introduced. The *Mathematics Framework* suggests that these unifying ideas be included by curriculum designers in their kindergarten through eighth grade programs:

For the Elementary Grades:

How many? How Much?

Finding, Making, and Describing Patterns

Representing Quantities and Shapes

For the Middle School Program:

Proportional Relationships

Multiple Representations

Patterns & Generalization

The framework recommends that the mathematics curriculum be organized into units of instruction. According to the document, "A typical unit consists of investigations, problems, and other learning activities, integrated with assessment, that develop depth of understanding and lead to complete work" (p. 89). Each unit, presented

in an engaging context, should have a distinct character, a clearly formulated purpose, and be long enough in duration to enable students to accomplish substantial work.

Several strands and one or more unifying ideas must be interwoven in each unit to ensure balance, depth, and connectedness, and a wide variety of activities related to the primary goal must be included. Units should help students see how mathematics is integrated in their lives and actively involve students in generating questions, experimenting with a variety of approaches, and interpreting and sharing results. The framework poses six questions to help gauge whether a unit idea is suitable:

1. Does the subject matter represent an important area of knowledge?
2. Does the mathematics arise naturally in the unit?
3. Are mathematical ideas integral to an understanding of the unit?
4. Does the unit have natural coherence?
5. Does the mathematics in the unit have important internal connections within mathematics?
6. Does the unit provide external connections to work in other disciplines?

The subject matter of units can be either concrete or abstract. Concrete units are devoted to topics outside mathematics, such as maps and scale drawing, and are important for a quantitative understanding of the world. Abstract units explore mathematics away from its application and help to develop an understanding of pure mathematics. Concrete materials are still manipulated in abstract units, but are used to learn something purely mathematical rather than practical. Regardless of whether a unit is more concrete or abstract, it must still develop all the dimensions of mathematical power, support independent and collaborative student work, encourage the students'

positive disposition towards mathematics, and take into account historical, societal, and career information.

The content included in a year's work should represent what is believed to be the most important mathematics for each grade level but should allow some flexibility in choice to make the mathematics more meaningful. The units should provide balance across the strands over the course of a year and progressively develop the depth of understanding of unifying ideas. Some material can be introduced outside of units and units may be distributed over time when it is beneficial to do so. Integrating mathematics with other school subjects is an important goal of the framework and units that have an interdisciplinary focus are encouraged.

Content of the Elementary Program

The *Mathematics Framework's* fourth chapter, "Mathematical Content in Kindergarten Through Grade Eight" , uses the standards established by the NCTM to determine what mathematics children should study during the elementary and middle school years. What follows is a list of the standards for the elementary level and a statement of what students should be able to do by the end of the fourth grade.

Standard 1: Mathematics as Problem Solving

- Use problem solving approaches to investigate and understand mathematical content.
- Format problems from everyday and mathematical situations.
- Develop and apply strategies to solve a wide variety of problems.
- Verify and interpret results with respect to the original problem.
- Acquire confidence in using mathematics meaningfully.

Standard 2: Mathematics as Communication

- Relate physical materials, pictures, and diagrams to mathematical ideas.
- Reflect on and clarify their thinking about mathematical ideas and situations.
- Relate their everyday language to mathematical language and symbols.
- Realize that representing, discussing, reading, writing, and listening to mathematics are a vital part of learning and using mathematics.

Standard 3: Mathematics as Reasoning

- Draw logical conclusions about mathematics.
- Use models, known facts, properties, and relationships to explain their thinking.
- Justify their answers and solution processes.
- Use patterns and relationships to analyze mathematical situations.
- Believe that mathematics makes sense.

Standard 4: Mathematical Connections

- Link conceptual and procedural knowledge.
- Relate various representations of concepts or procedures to one another.
- Recognize relationships among different topics in mathematics.
- Use mathematics in other curricular areas.
- Use mathematics in their daily life.

Standard 5: Estimation

- Explore estimation strategies.
- Recognize when an estimate is appropriate.
- Determine the reasonableness of results.
- Apply estimation in working with quantities, measurement, computation, and problem solving.

Standard 6: Number Sense and Numeration

- Construct number meanings through real-world experiences and the use of physical materials.
- Understand the numeration system by relating counting, grouping, and place-value concepts.
- Develop number sense.
- Interpret the multiple uses of numbers encountered in the real world.

Standard 7: Concepts of Whole Number Operations

- Develop meaning for the operations by modeling and discussing a rich variety of problem situations.
- Relate the mathematical language and symbolism of operations to problems and informal language.
- Recognize that a wide variety of problem structures can be represented by a single operation.
- Develop operation sense.

Standard 8: Whole Number Computation

- Model, explain, and develop reasonable proficiency with basic facts and algorithms.
- Use a variety of mental computation and estimation techniques.
- Use calculators in appropriate computational situations.
- Select and use computational techniques appropriate to specific problems and determine whether the results are reasonable.

Standard 9: Geometry and Special Sense

- Describe, model, draw, and classify shapes.

- Investigate and predict the results of combining, subdividing, and changing shapes.
- Develop spatial sense.
- Relate geometric ideas to number and measurement ideas.
- Recognize and appreciate geometry in their world.

Standard 10: Measurement

- Understand the attributes of length, capacity, weight, area, volume, time, temperature, and angle.
- Develop the process of measuring and concepts related to units of measurement.
- Make and use estimates of measurements.
- Make and use measurements in problem and everyday situations.

Standard 11: Statistics and Probability

- Collect, organize, and describe data.
- Construct, read, and interpret displays of data.
- Formulate and solve problems that involve collecting and analyzing data.
- Explore concepts of chance.

Standard 12: Fraction and Decimals

- Develop concepts of fractions, mixed numbers, and decimals.
- Develop number sense for fractions and decimals.
- Use models to relate fractions to decimals and to find equivalent fractions.
- Use models to explore operations on fractions and decimals.
- Apply fractions and decimals to problem situations.

Standard 13: Patterns and Relationships

- Recognize, describe, extend, and create a wide variety of patterns.

- Represent and describe mathematical relationships.
- Explore the use of variables and open sentences to express relationships.

The elementary program must integrate the eight strands of mathematics identified in the framework as well as the three unifying ideas that are focused on at this level. The framework recommends developing units of study related to the following subject matter:

Attributes and Classification

Understanding Number and Numeration

Understanding Arithmetic Operations

Dealing With Data

The Process of Measurement

Measuring Geometric Figures

Location and Mapping

Visualizing and Representing Shapes

Exchange

Games and Rules

Sharing

Content of the Middle School Program

During the middle school years, mathematical ideas introduced in earlier grades are revisited at a more abstract level. New mathematical concepts are encountered and students begin to expand their number sense beyond the realm of numbers. The practical power of mathematics is emphasized. By the end of the eighth grade, students should be able to do what is described in the NCTM standards for grades 5 through 8 listed below:

Standard 1: Mathematics as Problem Solving

- Use problem solving approaches to investigate and understand mathematical content.
- Format problems from situations within and outside mathematics.
- Develop and apply a variety of strategies to solve a wide variety of problems, with emphasis on multistep and nonroutine problems.
- Verify and interpret results with respect to the original problem situation.
- Generalize solutions and strategies to new problem situations.
- Acquire confidence in using mathematics meaningfully.

Standard 2: Mathematics as Communication

- Model situations, using oral, written, concrete, pictorial, graphical, and algebraic methods.
- Reflect on and clarify their thinking about mathematical ideas and situations.
- Develop common understandings of mathematical ideas, including the role of definitions.
- Use the skills of reading, listening, and viewing to interpret and evaluate mathematical ideas.
- Discuss mathematical ideas and make conjectures and convincing arguments.
- Appreciate the value of mathematical notation and its role in the development of mathematical ideas.

Standard 3: Mathematics as Reasoning

- Recognize and apply deductive and inductive reasoning.
- Understand and apply reasoning processes, with special attention being given to special reasoning and reasoning with proportions and graphs.
- Make and evaluate mathematical conjectures and arguments.

- Validate their own thinking.
- Appreciate the pervasive use and power of reasoning as a part of mathematics.

Standard 4: Mathematical Connections

- See mathematics as an integrated whole.
- Explore problems and describe results, using graphical, numerical, physical, algebraic, and verbal mathematical models or representations.
- Use a mathematical idea to further understanding of other mathematical ideas.
- Apply mathematical thinking and modeling to solve problems that arise in other disciplines, such as art, music, psychology, science, and business.
- Value the role of mathematics in our culture and society.

Standard 5: Number and Number Relationships

- Understand, represent, and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential, and scientific notation) in real-world and mathematical problem situations.
- Develop number sense for whole numbers, fractions, decimals, integers, and rational numbers.
- Understand and apply ratios, proportions, and percents in a wide variety of situations.
- Investigate relationships among fractions, decimals, and percents.
- Represent numerical relationships in one-dimensional and two-dimensional graphs.

Standard 6: Number Systems and Number Theory

- Understand and appreciate the need for numbers beyond the whole numbers.

- Develop and use order relations for whole numbers, fractions, decimals, integers, and rational numbers.
- Extend their understanding of whole number operations to fractions, decimals, integers, and rational numbers.
- Understand how the basic arithmetic operations are related to one another.
- Develop and apply number theory concepts (e.g., primes, factors, and multiples) in real-world and mathematical problem situations.

Standard 7: Computation and Estimation

- Compute with whole numbers, fractions, decimals, integers, and rational numbers.
- Develop, analyze, and explain procedures for computation and techniques for estimation.
- Develop, analyze, and explain methods for solving proportions.
- Select and use an appropriate method for computing from among mental arithmetic, paper-and-pencil, calculator, and computer methods.
- Use computation, estimation, and proportion to solve problems.
- Use estimation to check the reasonableness of results.

Standard 8: Patterns and Functions

- Describe, extend, analyze, and create a wide variety of patterns.
- Describe and represent relationships with tables, graphs, and rules.
- Analyze functional relationships to explain how a change in one quantity results in a change in another.
- Use patterns and functions to represent and solve problems.

Standard 9: Algebra

- Understand the concepts of variable, expression, and equation.

- Represent situations and number patterns with tables, graphs, verbal rules, and equations and explore the interrelationships of these representations.
- Analyze tables and graphs to identify properties and relationships.
- Develop confidence in solving linear equations, using concrete, informal, and formal methods.
- Investigate inequalities and nonlinear equations informally.
- Apply algebraic methods to solve a variety of real-world and mathematical problems.

Standard 10: Statistics

- Systematically collect, organize, and describe data.
- Construct, read, and interpret tables, charts, and graphs.
- Make inferences and convincing arguments based on data analysis.
- Evaluate arguments based on data analysis.
- Develop an appreciation for statistical methods as powerful means for decision-making.

Standard 11: Probability

- Model situations by devising and carrying out experiments or simulations to determine probabilities.
- Model situations by constructing a sample space to determine probabilities.
- Appreciate the power of using a probability model by comparing experimental results with mathematical expectations.
- Make predictions based on experimental or theoretical probabilities.
- Develop an appreciation for the pervasive use of probability in the real world.

Standard 12: Geometry

- Identify, describe, compare, and classify geometric figures.

- Visualize and represent geometric figures, with special attention to developing spatial sense.
- Explore transformations of geometric figures.
- Represent and solve problems using geometric models.
- Understanding and apply geometric properties and relationships.
- Develop an appreciation of geometry as a means of describing the physical world.

Standard 13: Measurement

- Extend their understanding of the process of measurement.
- Estimate, make, and use measurement to describe and compare phenomena.
- Select appropriate units and tools to measure to the degree of accuracy required in a particular situation.
- Understand the structure and use of systems of measurement.
- Extend their understanding of the concept of perimeter, area, volume, angle measure, capacity, and weight and mass.
- Develop the concept of rates and other derived and indirect measurements.
- Develop formulas and procedures for determining measures to solve problems.

At the middle grade level, mathematical content must include each strand identified in the framework and be organized around three new unifying themes: (a) proportional relationships, (b) multiple representations, and (c) patterns and generalization. The *Mathematics Framework* recommends the following units as a means for organizing mathematics in the middle grade curriculum:

Objects, Shapes, and Containers

Maps and Scale Drawings

Growth

Motion

Expressing Proportional Relationships

The Montessori Mathematics Curriculum

The Montessori mathematics curriculum is a comprehensive, multidimensional system for learning mathematical concepts based on the needs and developmental characteristics of preschool and elementary aged children. Designed as a means for assisting children in their total mental development, the method focuses on fostering depth of understanding and the discovery of mathematical ideas rather than the memorization of isolated facts and procedures. Instruction is individualized and manipulative materials, each isolating a single idea, are used to help lead the child from sensorial exploration to an abstract understanding of mathematical concepts. Students move through the curriculum at their own pace and are able to discover and correct their own mistakes through the built-in control of error incorporated in each material. A wide range of activities, differing in depth, complexity, and scope, are introduced to provide the child with repetition of basic skills in a variety of contexts.

The materials used in the Montessori mathematics curriculum present ideas in concrete form and are sequenced to gradually move the student toward abstract comprehension. A material itself may offer various levels of difficulty to help the child reach an internalized understanding of a concept or the child may be moved toward abstraction by working through a series of materials that become increasingly abstract. In addition to directly preparing the child for the next material in a series of exercises, each material also provides a foundation for further mathematical activities by incorporating

concepts that are absorbed by the child at a sensorial level. For example, while the direct aim for a set of numerals cut from sandpaper is to introduce the symbols for the quantities from one to nine, the indirect aim is to physically prepare the child for writing the numerals at a later time. It is the accumulation of sensorial knowledge, as well as the child's direct experience with sequential materials, that lays the foundation for an abstract understanding of mathematical concepts in the Montessori system of education.

The high degree of consistency found between the materials used in the Montessori mathematics curriculum also helps children in the process of attaining abstract understanding. The uniformity of size and color within the materials, such as all the bead material being made of the same sized beads and the consistent color coding of the hierarchy designations, facilitates the transition from one material to the next and adds an element of coherence to the curriculum as a whole.

The Montessori elementary mathematics curriculum builds directly on the work completed by the child in early childhood classrooms. At the preschool level, the child engages in self-construction and is in a critical or sensitive period for absorbing mathematical concepts. Basic mathematical ideas are presented in concrete form and materials are introduced to individual or small groups of children depending on each child's experience and level of maturity. In each group of work, the quantity is given first and is then followed by an introduction to the written symbol. The work culminates in an activity combining the two. As the child progresses through the curriculum, repeating activities at her own discretion, she is led toward an understanding of basic mathematical processes and is prepared for the advanced mathematic and logical exercises she will encounter at the elementary level.

The study of mathematics in the elementary classroom continues to focus on the use of manipulative materials that lead the child toward abstraction, but differs according to

the developmental characteristics of the 6 to 12 year-old child. Elementary aged children are socially oriented and enjoy using their ability to reason and to complete large, challenging projects. To cater to these characteristics, the Montessori mathematics curriculum encourages students to collaborate on activities and to derive for themselves the formula, algorithm, or rule necessary for abstractly completing a mathematical procedure. Many exercises allow for the possibility of extensive work while the flexible structure of classroom time enables students to complete large projects and investigations. Presentations are usually given to small groups of children and repetition at this level is provided through a variety of activities including those initiated by the students themselves.

Mathematical work at the elementary level is also set apart from the early childhood program by being viewed from an historical perspective. Throughout the Montessori system, a general impression of the whole is introduced before an analysis of the parts is undertaken. In the primary classroom, a view of the whole in mathematics is given by introducing the decimal system using concrete representations of the hierarchy of numbers before advanced counting and the operations of addition, subtraction, multiplication, and division are presented. At the elementary level, a vision of the whole in mathematics is obtained by placing mathematics in its historical context. *The Story of Numbers*, presented at the beginning of each school year, introduces the child to the major systems of counting that have evolved over time and how these systems developed to fulfill basic human needs. The relevance of mathematics in human society is emphasized in the story and a connection between the study of mathematics and other curriculum areas is established. Later presentations on the history of measurement and the history of geometry provide further details in relation to the whole and continue the child's exploration of historical mathematics.

The study of geometry forms a separate curriculum area in the Montessori system of education. However, geometry concepts are introduced and examined in the same manner as general mathematical ideas and the two curriculums are explored concurrently throughout the school year. In both areas children are encouraged to initiate their own follow-up activities after presentations and to share their completed projects with others. Independent work in both areas helps the child to relate mathematics to the real world and provides opportunities for working with mathematical ideas in meaningful situations. Developing depth of understanding and the reasoning abilities of the child are the primary aims of both curriculum areas.

The following is a description of the four areas of study that collectively form the Montessori mathematics curriculum: (a) early childhood mathematics, (b) elementary mathematics, (c) early childhood geometry, and (d) elementary geometry.

The Early Childhood Mathematics Curriculum

The study of mathematics in the early childhood Montessori classroom begins with indirect preparation and can then be divided into eight areas of work: (a) numbers to ten, (b) introduction to the decimal system, (c) teens and tens, (d) simple counting, (e) memory work, (f) fractions, (g) decimal system operations, and (h) activities leading to abstraction.

Indirect Preparation

The exercises of practical life and the sensorial materials indirectly prepare the child for mathematical thinking in the Montessori preschool classroom. Practical life activities involve the children in caring for themselves and the environment and provide indirect preparation for mathematics by developing the child's concentration,

coordination, sense of order, and logical and sequential thought patterns. The sensorial materials allow children to classify sensorial impressions in an organized, orderly manner and enable the child to work in quantities from one to ten in several dimensions. Activities in both areas help the child to move with precision and to work toward exactness of movement and thought.

Numbers to Ten

The activities in the first area of work, numbers to ten, introduce the child to units of quantity using a sequence of materials that increases in difficulty and slowly leads the child to a conceptual understanding of number. A set of ten wooden rods in graded lengths from one decimeter to one meter is used to help the child learn the names of the numbers and that each number represents a quantity separate and distinct from all the others. The rods are painted red and blue in alternate decimeters--the number of partitions in each rod represents the number of the rod--and the child is given the name for two or three numbers at a time through activities involving manipulation of the rods. A set of sandpaper numerals is then used to introduce the symbol for the quantities the child has come to recognize and eventually a presentation is given to associate the quantities represented by the number rods with their written symbol.

A material called the spindle boxes is then demonstrated to the child to illustrate number as a collection of items and to introduce zero. By placing the corresponding quantity of spindles in compartments marked from zero to nine the child is provided with further experience in counting and in associating quantity and numeral. The fixed order of the numerals helps the child to learn the numbers in sequence and prepares her for the next exercise--the counters and numerals--in which both the order and the quantity must be established by the child. A bead stair containing bead bars of different lengths and

colors ranging from one to nine can also be introduced to provide further sensorial experience with counting units.

Once the child is able to count independently and has some recognition of number outside of a sequence, she can be asked to retrieve a specific number of objects from a different location in an activity called the memory game. This final exercise in the numbers to ten sequence provides the child with practice in counting and helps her to develop a memory of the numbers from zero to ten.

Although many Montessori teachers supplement these basic exercises with additional zero to ten counting activities in their programs, the materials described here form the basic core for learning the numbers of our base ten system and help the child to construct an understanding of number through direct sensorial experience with concrete materials.

Decimal System Introduction

Two sets of materials, the golden beads and the number cards, introduce the child to the quantities and symbols of our decimal system. The golden bead material consists of individual beads to represent units and beads strung together on wire to make up 10 bars, 100 squares, and 1,000 cubes. The number cards consist of four sets of cards representing the hierarchy of numbers in the base ten system and are as follows: (a) one to nine in green, (b) 10 to 90 by tens in blue, (c) 100 to 900 by hundreds in red, and (d) 1,000 to 9,000 by thousands in green.

The child is first introduced to the decimal quantities of 1, 10, 100, and 1,000 through a naming activity using a unit bead, a ten bar, a hundred square, and a thousand cube. The written symbol for each quantity is then presented to the child using the unit, ten, hundred, and thousand number card and finally, a demonstration is given to associate

the quantities with their symbol. Once the child is familiar with the decimal categories, a lesson is given to illustrate that in order to go beyond nine in any one category, it is necessary to go to the next higher category.

Further sensorial experience with the decimal system and its numerals is provided through a series of layouts. During the first layout, the quantity represented by the number cards is laid out in a grid formation using a large quantity of the golden bead material. The number cards are laid out in a similar fashion in the second layout, and in the third, both quantity and symbol are combined to introduce the association between quantity in the decimal system and its symbol. These exercises provide the child with a visual representation of the decimal system and its relative proportions and reinforce that if you go beyond nine in one category you need to go on to the next category. Once the child has experienced the full decimal layout, she can begin to compose numbers by combining number cards and finding the corresponding quantity or by placing quantities from more than one category together and locating the appropriate number cards.

Teens and Tens

Activities in the next area of work, teens and tens, run parallel with the early decimal system presentations and aid the child in her counting and construction of numbers between 11 and 100. During the first activity the child constructs both the quantity and symbol for the numerals from 11 to 19 using a material called the teen boards. After the child has practiced with the teen boards, the ten boards are presented to introduce the concept that units can be added to tens and to explore the numbers from 11 to 99.

Practice in counting from one to a hundred is provided through a material called the hundred board and through a set of activities called linear and skip counting. The

hundred board enables the child to place tiles with the numerals from one to one hundred printed on them on a grid board according to a control chart that illustrates the correct layout of the tiles. Linear counting involves the child in counting and labeling different bead chains from the bead cabinet material, which consists of short chains of bead bars representing each numeral squared, and long chains of bead bars representing each numeral cubed. Skip counting is undertaken by reading the labels that have been placed by the child while linear counting. For example, once the five short chain has been counted and labeled, the labels, placed next to the last bead in each bar, can be read back--5, 10, 15, 20, and 25--to demonstrate skip counting. These activities provide the child with practice in counting and indirectly prepare her for later activities in multiplication, squaring, and cubing.

Simple Counting

A variety of activities that prepare the child for addition, subtraction, multiplication, and division make up the section of work entitled simple counting. Although the child will have already experienced addition sensorially by combining various materials such as the number rods, the child's first formal introduction to the concept of addition is given through two materials--the snake game and the addition strip board. During the snake game, the child places colored bead bars of different lengths in a zigzag formation and turns the snake golden by counting the beads up to ten and replacing each group of ten with a gold ten bar. Any remaining beads in a bar are counted and a placeholder procedure is introduced. By replacing the colored bead bars with the gold ten bars the child visually experiences equivalence and is familiarized with the possible number combinations equal to ten.

The addition strip board consists of a handboard chart divided into squares with the numbers 1 to 18 printed across the top. Two sets of numbered strips, one in red, the other in blue, are arranged on the board in different formations to help the child learn the sequence of addition combinations from one to nine. The subtraction strip board is used in a similar fashion and provides practice with the subtraction tables from 1 to 18. However, the subtraction strip board is a more advanced material and may not be introduced until the elementary years.

Multiplication and division are introduced to the preschool Montessori child using the multiplication board and the unit division board. By distributing small beads on each of the perforated boards, the child kinesthetically experiences multiplication and division and is helped to develop a memory of basic multiplication and division combinations. Further practice with multiplication is provided through a series of bead bar layouts, which sensorially and visually demonstrate the multiplication tables and equivalencies.

Memory Work

The child is assisted in her memorization of arithmetic facts through a collection of charts called the memorization charts. For each operation there is a set of charts that helps the child progress from a practicing stage to complete memorization of combinations. As the child becomes more proficient in each operation, the chart they work with becomes more abstract until the final chart, which is blank, is presented and the child must fill in the answers herself from memory.

Fractions

A sensorial introduction to the concept of fractions is given to the youngest children in the Montessori preschool classroom through four large wooden skittles that represent a whole, halves, thirds, and fourths. The tactile and visual exploration of fractions is then

continued through the fraction circles, which consist of ten metal frames each containing a 10 cm circular inset. One inset is a whole circle while the other circles are divided respectively into two, three, four, five, six, seven, eight, nine, and ten equal parts. Each circle segment has a knob enabling the child to remove and replace the pieces. The circle pieces can then be used to introduce the names of the fraction parts and can be employed in a variety of activities to prepare the child for the advanced fraction exercises she will encounter during the elementary years.

Decimal System Operations

The child's work with the decimal system continues through a series of activities exploring the processes of addition, subtraction, multiplication, and division. The same material, including a bank of golden bead material and three sets of number cards, is used to carry out all the exercises and a similar format and progression is followed for each operation.

Static addition, which does not require carrying from one category to the next, is presented first and should be given to a group of children who are experienced with associating large quantities with their numerical symbols. A problem is presented, e.g. $3,326 + 2,431$, and the children are asked to obtain the number cards and corresponding quantity of material for each addend. The quantities are then combined and the answer is laid out using the third set of number cards. In dynamic addition, the next presentation, the procedure is the same except the problem given will require regrouping from one hierarchy to the next. Both exercises give a sensorial impression of addition as a putting together of quantities, and reinforce the concept of place value.

Static and dynamic subtraction, multiplication, and one digit division follow the same process while two digit division is presented using only the bead material in a related manner to provide the child with a sensorial introduction to long division.

Activities Leading to Abstraction

The final group of exercises in the early childhood Montessori math curriculum provide further experience with arithmetic and move the child closer to abstraction and symbolic representation. Three activities--the stamp game, the dot board, and the small bead frame-- make up the area of work that leads the child to abstraction. While each of these materials is initially introduced using addition, they can also be used to perform subtraction and multiplication, and in the case of the stamp game, division.

The stamp game is used by an individual child to do addition in the same manner as in the decimal system operations only "stamps" are used to represent the golden bead material in the following manner: (a) green stamps with 1 written on them represent units, (b) blue stamps with 10 printed on them stand for a ten bar, (c) red stamps with 100 written on them represent a hundred square, and (d) green stamps with 1,000 written on them stand for a thousand cube. The dot game is also representational and introduces the child to column addition and the decimal category of 10,000 using paper specifically prepared for this exercise. Rather than combining the quantities of two addends using the golden bead material or stamps, in this activity the child combines two amounts by placing different colored dots representing the decimal categories in the appropriate columns. Dynamic addition is carried out by crossing out any rows of ten found in a column and placing a one for each row in the next higher category.

A further step toward abstraction of addition is taken through the use of the small bead frame, which consists of a wooden frame with four wires across, each strung with

10 beads and representing the hierarchy of numbers from units to thousands. A problem is laid out by sliding the corresponding beads from the left of the frame to the right for one addend beginning with the units and then adding to these each category from the second addend and carrying while doing so if necessary. The child may then count the beads in each category on the right of the frame to arrive at the sum. The procedure is less time consuming than the previous addition exercises and directly prepares the child for abstract computation.

The Elementary Mathematics Curriculum

Montessori mathematics at the elementary level begins with the *Story of Numbers* and can then be divided into 13 primary areas of work: (a) numeration, (b) multiplication, (c) division, (d) fractions, (e) decimal fractions, (f) squaring and cubing, (g) square root and cube root, (h) powers of numbers, (i) negative numbers, (j) non-decimal bases, (k) word problems, (l) ratio and proportion, and (m) algebra. The beginning work in most sections is introduced during the child's first few years in the elementary classroom while some of the later activities may not be presented until the fifth or sixth grade level. General age levels for lessons are occasionally given and prerequisite work is described where appropriate.

The Story of Numbers

Mathematics at the elementary level is introduced and explored from a historical perspective through a narrative called *The Story of Numbers*. *The Story of Numbers* presents an overview of early number systems from the Mayans to the Romans and investigates the origins of our present system of numeration. The history of mathematics provides a foundation for all the child's work in mathematics and serves as a means for

relating math to every other area in the Montessori curriculum. Students are encouraged to initiate their own follow-up after the story has been told.

Numeration

The area of work called numeration explores our decimal system and its properties beyond the child's experiences in the preschool Montessori classroom and sensorially introduces multiples, factors, and the concept of measurement.

An expanded view of our decimal system is presented both physically and visually through the wooden hierarchy material that consists of seven geometric forms representing the hierarchy of numbers from a $\frac{1}{2}$ cm unit cube to a 50 cm million cube. This dramatic material emphasizes the relative size and shape of one category to another and is color-coded (green cubes, blue bars, and red squares) to introduce families of numbers, i.e. the simple family, the thousand's family, and the million's family. A set of numeral cards with 1, 10, 100, 1000, 10000, 100000, and 1000000, printed on them is included to familiarize the child with the symbols for the categories represented by the material. This material gives a clear visual representation of the hierarchy of numbers and directly prepares the child for working with numbers beyond the thousands category.

The commutative and distributive laws of multiplication are brought into the child's consciousness through a series of exercises using the colored bead bars from 1 to 10, number cards from 1 to 9, and later the golden bead material for multiplying with numbers greater than units. Multiples and factors, including activities introducing the lowest common multiple and the highest common factor, are explored using colored pegs and a peg board, while measurement is examined through a story of its history and a variety of exercises focused on length, volume, weight, time, angles, money, temperature, etc. Work in all of these areas provides sensorial experience with the properties of our

number system and either directly or indirectly prepare the child for the later mathematical work they will encounter in the curriculum.

Multiplication

Multiplication at the elementary level builds on the child's experiences with the decimal system operations and the small bead frame in the preschool Montessori classroom and is investigated primarily through the use of four materials: (a) the large bead frame, (b) the checker board of multiplication, (c) the flat bead frame, and (d) the bank game.

The large bead frame is used in the same manner as the small bead frame but consists of seven strings of ten beads representing the hierarchy of numbers from units to millions rather than four strings representing units to thousands. The expanded size of the frame allows the student to practice reading and writing large numbers and helps to reinforce place value and that 10 in one category makes up one of the next higher category. A series of activities is completed on the frame culminating in an exercise introducing two-digit multiplication both sensorially and as written out through specifically prepared notation paper.

The checker board of multiplication provides additional manipulative experience with long multiplication and moves the student toward abstraction by becoming less concrete as the child gains proficiency with her multiplication facts. The checker board exercises lay a foundation for completing a geometrical form of multiplication on graph paper and indirectly prepare the child for the squaring of numbers, square root, and algebra.

The flat bead frame, in conjunction with the bank game, is introduced as the last step in leading the child toward abstract multiplication. Whereas the large bead frame

contains seven strings of colored beads, the flat bead frame has nine wires of ten golden beads and is manipulated to provide the child with the partial products of a problem as they are recorded on paper. As the student becomes more able to calculate in her head, use of the frame becomes unnecessary and a step closer to abstraction of multiplication will have occurred. The bank game, used by a group of children, provides additional practice with long multiplication using a lay out of number cards from 1 to 9 million, and reinforces the changing process and what is meant by category multiplication. Both materials help the child to construct her own knowledge of the multiplication process and are used over an extended period of time to meet the individual needs of each student.

Division

Both distributive and group division are introduced at the elementary level through a series of exercises that bring the child to an abstract understanding of division. Distributive division, in which a quantity is shared so that each unit receives the same amount, is explored through a material called the racks and tubes. By distributing different colored beads representing the categories of numbers on one or more division boards while using the racks and tubes the child is able to perform short and long division and is introduced to the recording process that will eventually enable her to divide abstractly. The student's work with distributive division is followed by an introduction to group division in which the answer is derived by subtracting the divisor from the quantity as many times as it takes to be used up. The stamp game material previously used in the primary classroom is used to concretely illustrate this process and to help the child with the estimation procedure necessary for completing long division on paper. A series of divisibility exercises is also explored in this area of work to acquaint children with the rules of divisibility and to excite interest in the study of mathematics.

Fractions

The fraction metal insets introduced at the primary level are used as a starting point for almost every fraction concept explored in the elementary classroom. Beginning with an introduction to the quantity, symbol, and language of fractions, and progressing to activities of equivalence, simple operations, adding and subtracting with different denominators, and various multiplication, division, and word problem exercises, the metal insets provide a sensorial basis and sense of continuity for all the fraction work undertaken by the child at this level. Once a concept has been introduced using the insets, the student may continue to explore using the material or choose to create her own booklet or chart as a follow-up activity. The sequence of presentations helps to ensure that the child is adequately prepared for an activity before it is introduced and slowly moves the child toward more difficult exercises as an understanding of the more basic concepts is obtained. A set of charts illustrating different fraction concepts can be hung on the wall during the child's study and used for recalling information as necessary.

Decimal Fractions

Decimal fractions are introduced after the student has had experience with multiplying and dividing and has worked with the fraction insets. Small wooden cubes color coded to represent the hierarchy of decimal numbers from one-tenth to one-hundred thousandth are used throughout the study of decimal fractions in combination with the decimal fraction board--a working board containing columns representing whole and decimal numbers on which the decimal cubes, corresponding numeral cards, and colored whole number beads may be placed. Once a set of initial presentations introducing the quantity and symbols for decimal fractions has been given, the decimal board is used to introduce the formation and reading of decimal numbers and to perform addition,

subtraction, multiplication, and division operations. The hierarchy of numbers as existing even in decimal fractions--that ten of this category equals one of the next higher--is emphasized through these operations, and the student is shown how to complete the processes on paper. Further experience with multiplying whole and decimal numbers is provided through the decimal checker board. A procedure for determining the rule for multiplying and dividing decimal fractions can then be demonstrated as well as an activity for converting common fractions to decimal fractions.

Squaring and Cubing

The child's work with squaring and cubing in the elementary classroom begins with a sequence of activities introducing the squares and cubes of numbers using the bead cabinet material which consists of different colored bead chains, squares, and cubes for each number, 1 through 10. Once the concept, notation, and numerical values first for squares, then for cubes, has been presented with the bead material, the child can be shown a series of games and exercises that explore squares, cubes, and the multiplication tables both sensorial and numerically. Different power scales and decanomial lay outs can be shown to the child as well as methods for adding, subtracting, multiplying and dividing the squares and cubes of numbers. These activities are used to arouse the child's interest and to provide a bases for the more structured squaring and cubing exercises and the student's later work in algebra.

An extensive series of activities exploring binomials and trinomials both numerically and algebraically continues the child's work with squaring and cubing. An assortment of materials, including the bead squares, the colored bead bars, the golden bead material, and the colored pegs and peg board is used to progress through the squaring exercises while the wooden cubing material, which consists of one cube and 27

squares for each of the powers from 1 to 9, is used for many of the cubing activities. The binomial and trinomial cubes previously introduced as sensorial puzzles in the preschool Montessori classroom are reintroduced at this level to demonstrate cubing algebraically and a second trinomial cube, color-coded to represent each category value from a unit to ten thousand, is used to illustrate cubing a trinomial hierarchically. These exercises allow the student to discover relationships between the component parts of squares and cubes and prepare them for abstract analysis of polynomials.

Square Root and Cube Root

A conceptual understanding of square and cube root is attained by the student in the Montessori classroom through a succession of activities using the colored pegs and peg board to investigate square root and the wooden cubing material to examine cube root. A lesson introducing the concept, language, and notation begins both the study of square root and cube root and in both areas of work the child moves from concrete exploration with the materials toward discovering the algorithm necessary for completing the process on paper. The manipulatives enable the student to find the square and cube roots for progressively more difficult problems and by paralleling the algorithm in their use, prepare the child for arriving at her own understanding of the abstract procedure. The exercises also provide the child with practice in place value and multiplication.

Powers of Numbers

The student's work with the powers of numbers begins after the exercises with squares and cubes through the use of a material called the power of two cube. Consisting of cubes and prisms, each a progression of squaring the previous piece, the cube concretely demonstrates the powers of two and is used to introduce the terminology of base and exponent. Bases other than two are examined using a large quantity of small

white cubes, and the hierarchical material is reintroduced as demonstrating the powers of ten. The child can then be shown how to complete operations using exponential notation and can be led to discover the rule for multiplying and dividing numbers of the same base.

Negative Numbers

Negative numbers are introduced in the elementary classroom through a variation on the snake game, which is presented at the primary level to reinforce the process of addition. Negative bead bars are included in the procedure during the negative snake game to visually demonstrate that negative numbers decrease the quantity during addition and to emphasize that numerically equal positives and negatives cancel one another out. Once the child has sensorially experienced negative numbers, she is shown how to record the snake on paper and is later introduced to subtracting, multiplying, and dividing negative numbers using concrete materials. The student continues to work with the manipulatives until they are no longer needed and is encouraged to derive the rule for completing operations with sign numbers through her own explorations.

Non-decimal Bases

Non-decimal bases are introduced after the child has worked extensively with the decimal system and is aware of the geometric shapes of the various powers and that we have a place value system where zero is necessary. The numeration of non-decimal bases is examined by counting with the bead material on a number base board that has been divided into four categories: (a) units, (b) bars, (c) squares, and (d) cubes. For example, when counting in base five, unit beads up to four are placed in the unit column and recorded one at a time as 1,2,3,4. As a fifth unit bead is added, the five units are exchanged for a five bead bar, which is placed in the bar column, and the number 10 is

recorded to illustrate one bar and no units. As another unit is added to the unit column the number 11 is recorded and so on. Once the student is comfortable with counting in non-decimal bases, a series of charts can be presented to assist the child in performing operations in bases other than our own, and techniques for converting from a given base to base ten and vice versa can be presented. These exercises are presented to arouse the interest of the child and to expand their perception of what is meant by a number system.

Word Problems

Word problems should ideally be introduced through practical applications in the classroom but may be developed if they don't occur on their own. The student should be given the steps necessary for solving a problem and once carried out, the answer should be checked against what is known to determine if the solution makes sense.

Two kinds of problems--velocity, distance, and time; and interest, rate, time, and principal---are included in the elementary curriculum. These are given to the child in three levels beginning with a sensorial introduction at an early age where labeled tickets and the golden bead material are used to help the child set up the problem and determine the solution for each variable included. At the second level the student is helped to identify more precisely what was done arithmetically, and at the third level, the rule or formula for the problem is presented.

Ratio and Proportion

The child's study of ratio moves from a concrete introduction using the colored pegs on the peg board through a series of exercises that explores the arithmetical recording of ratio, ratio written as fractions, ratio stated algebraically, and various word problems where practical applications of ratio are investigated. Proportion is introduced after the student has studied ratio and is able to balance equations. Various objects in the

environment such as a one bead bar and a five bead bar, geometric figures which are equal in proportion, the power of two cube, etc., are used to illustrate proportional relationships and to provide a foundation for calculating arithmetically and algebraically with proportion. The student's work in this area is completed by applying proportion to word problems or in problem situations occurring naturally in the classroom.

Algebra

Children are introduced to algebra in the Montessori classroom once they are able to write formulas in word problems and can perform operations in fractions and negative numbers. In the first series of activities the child is shown how to balance an equation that has been laid out in bead bars when something has been added or subtracted to one side or when one side has been multiplied or divided by a number. The student then explores operations with equations and is introduced to algebraic word problems. These activities provide concrete experience with statements of equality and form a basis for the child's later work with algebra.

The Montessori Geometry Curriculum

The study of geometry in the Montessori method focuses on leading the child from a sensorial foundation in two and three dimensional forms to the discovery of geometrical relationships and abstractions based on the child's explorations. Concrete materials at both the early childhood and elementary levels help bring the child to a conceptual understanding of geometry and stimulate the child's mental development by providing experience with logical reasoning, problem solving, deduction, and synthesizing. The elementary materials supplement those presented at the preschool level and familiarize the student with the principles, symbols, and language of plane and solid geometry.

Geometry presentations are given to small groups and children are encouraged to complete their own follow-up work. Classified nomenclature material including pictures, separate labels, and definition booklets illustrating geometry concepts in all areas of study can be made available for the child's use. Geometry charts showing equivalence, similarities, equalities, and combinations can also be presented to inspire creative activity by the student.

The Early Childhood Geometry Curriculum

A foundation for the study of geometry at the elementary level is established in the preschool Montessori classroom through specific sensorial, language, and mathematics activities. Both direct and indirect preparation for geometry is provided in these curricular areas through the use of manipulative materials that help the child to focus her observations and to clarify her sensorial impressions.

Three materials in the sensorial area of the early childhood Montessori classroom--the geometry cabinet, the geometric solids, and the constructive triangles--directly prepare the child for the geometry he will encounter at the elementary level. The geometry cabinet consists of a cabinet with six drawers containing thirty three geometric insets and frames and is used to introduce the child to the shapes and language of plane geometry. The geometric solids help to develop the child's visual perception and muscular-tactile sense of ten common solid forms, while the constructive triangles can be manipulated to demonstrate that all plane geometric figures can be constructed from triangles. The child's work in all three areas helps him to form a basic knowledge of geometric shapes and forms and lays a foundation for the abstract geometry he will later encounter.

Indirect preparation for elementary geometry is provided through various other sensorial activities, the metal insets, geometry related classified card material, and mathematical exercises with the bead material. Spatial relationships between forms are revealed through the child's creative work with such sensorial materials as the pink tower and the broad stair. These materials provide concrete experiences with geometric forms and help to develop the child's visual discernment. The metal insets, found in the language area of the classroom, allow the child to draw and fill in common geometric figures, while the classified card material geared toward geometry gives the child the language for the various parts of geometric shapes. The golden bead material and the bead cabinet activities in the math curriculum also provide sensorial experience with geometric forms and prepare the child for relating geometry to multiplication.

The Elementary Geometry Curriculum

Geometry at the elementary level can be divided into six areas of work: (a) the study of line, (b) the study of angles, (c) polygons, (d) equivalence, (e) area of plane figures, and (f) solid geometry. Just as the child's elementary mathematics work is initiated by a story outlining the history of mathematics, the geometry curriculum at the elementary level also begins with an historical account of the development of geometry. Once a story describing the history of geometry has been presented, work in all other areas of the curriculum can be undertaken. The sequence of geometry presentations will differ according to the interests of the child and not all areas need to be introduced with each student as long as the appropriate public school curriculum is covered.

The Study of Line

In the study of line the child is introduced to the concept and language of lines through the use of concrete materials and various naming activities. No more than three concepts are introduced at a time and terminology is always given in conjunction with a concrete visual impression. For example, to present the idea of a line segment, a piece of string is marked, then cut, in two places to demonstrate that a line segment has two end points. The four areas covered in this section include:

Concept of Lines: straight line, ray, line segment

Line Position: vertical, horizontal, oblique

Positions of Two Straight Lines: parallel, divergent, convergent

Intersecting Lines: perpendicular, oblique

The Study of Angles

The child's study of angles includes eight exercises introducing and exploring the characteristics of angles and a set of activities that sensorially prepare the student for the theorems of angles. The geometric sticks, which consist of colored sticks of different lengths that can be connected through holes at the ends of each stick, are used to demonstrate different kinds of angles and are connected to illustrate the application of angles to the naming of different kinds of triangles, e.g. obtuse, scalene triangle; acute, isosceles triangle. The measurement of angles is introduced through a metal frame, calibrated in 360 degrees, into which fraction pieces can be placed and measured accordingly. Angles can be added and subtracted using the Montessori instrument for measuring angles, and eventually the student can be shown how to use a protractor to measure and draw angles of a particular size. The terminology for interior and exterior

space of line is presented using the geometric sticks and a cutting and matching exercise during the sensorial preparation for theorem of angles activities.

Polygons

The concept and nomenclature of both polygons and circles is explored in the polygon area of the geometry curriculum. In the first activity the terminology of various polygons is presented to the child as each shape is constructed using the geometric stick material. Various exercises are undertaken to acquaint the student with the different forms, including the special names given to quadrilaterals, and a second set of lessons that examines the nomenclature of polygons (side, perimeter, angle, area, vertex, base, altitude, etc.) is presented. A similar presentation is given to introduce the nomenclature of a circle and two additional activities can be initiated to investigate the relationship between a line and a circle, and the relationship between two circles. These activities provide experience in the construction and analysis of plane geometric figures and establish a foundation for the student's later work in area and solid geometry.

Equivalence

In the elementary Montessori classroom the student explores equivalence through three groups of activities. In the first series, equal, similar, and equivalent figures are examined using two sets of divided squares--one containing rectangles and squares of different sizes, the other, triangles. Once the child is able to identify equal and similar figures, equivalence is demonstrated by placing first a rectangular half over a whole square, then a triangular half over the same square and noting that the halves are equivalent because they have the same size despite their different shapes.

In the next sequence of activities, the child further explores equivalent figures using the constructive triangle material first introduced in the early childhood class. After

experience in this area, equivalence with the Pythagorean theorem is introduced using a set of three metal plates containing insets that demonstrate different applications of the theorem. Work in this area is extended through a number of activities illustrating the theorem with the constructive triangles. The student's experience with equivalence directly prepares her for the study of area and the abstract geometry she will encounter at the middle school and secondary level.

Area of Plane Figures

The area of plane figures, including the circle, is explored through a sequence of activities that move from purely sensorial exercises to those where the formula for determining the area of different geometric forms is derived. In the first set of activities, the child is prepared for finding the area of plane figures through a study of the relationship of lines (base and height) in equivalent figures. Thirteen metal plates containing interchangeable insets are used to demonstrate the equivalence between geometric forms and to help the student discover the rules governing these equivalencies.

In the next set of exercises the concept of area of plane figures is introduced through the yellow area material which consists of a collection of movable figures that can be assembled into a parallelogram and three kinds of triangles and then converted into rectangles to demonstrate in concrete form different formulas for calculating area. Further experience with deriving the formulas for area are obtained by analyzing the metal plate material used to show equivalence.

The circle is introduced in the next set of activities. To help the student discover pi, the circumferences of various sized circles from the polygon drawer of the geometry cabinet are recorded each on a separate line. The number of diameters that fit into each circle's line is then counted and the child is helped to see that for every circle, the

diameter fits three times and a little more. A second exercise is then given to demonstrate how to find the area of a circle using two circles divided into equal parts that are fit together to resemble a rectangle. By associating the height and base of the rectangle with the radius and circumference of the circle the student is provided with a concrete bases for determining the formula necessary for calculating the area of a circle.

Solid Geometry

The child's exploration of solid figures continues at the 6 to 12 year old level through a study of volume and total area. The formula for calculating the volume of solid figures is arrived at through a series of exercises beginning with ample experience analyzing forms constructed with small cubes. The procedure for computing the volume of a solid prism is investigated in a subsequent lesson and an activity focusing on the equivalence between prisms with different bases is presented to help the student calculate the volume for a variety of prisms. A set of hollow solids that can be filled with sand are then used to help the child discover the formula for finding the volume of a pyramid. The study of volume culminates in an activity where the child is led to determine the volume formula for the cylinder and cone of the geometric solids.

The area of solids is examined by drawing the outline of figures from the geometric solids on large sheets of paper. Once the surface area has been laid out in two dimensional form, the child can apply what she knows about calculating the area of plane figures to determining the formula for finding the total area of solids. Both series of exercises in the solid geometry area of work enable students to discover the necessary formulas themselves and to apply these formulas to three-dimensional forms found in the environment.

The State and Montessori Mathematics Curriculums Compared

The *Mathematics Framework for California Public Schools* is devoted to extensive reform in mathematics education and presents guidelines for developing programs and instructional materials that support the recommendations and standards of achievement established by the NCTM. The Montessori mathematics curriculum is itself a detailed program for mathematics instruction and differs in emphasis, organization, and structure from the approach outlined by the state. Despite different views on how a mathematics program should be structured, many aspects of the state and Montessori curriculums are similar. These similarities include: (a) how children learn mathematics, (b) what characteristics are essential to mathematics programs, (c) the role of the teacher in mathematics education, and (d) general areas of mathematical content.

Similarities

Both the public school and Montessori method acknowledge that children are naturally motivated to learn and actively create their own understanding of the world through direct, personal experience. The importance of cultivating higher-order thinking even at the lower elementary level is recognized by each curriculum, and both emphasize making a connection between mathematics and the student's own experiences. Central to both approaches is the use of concrete materials to help illuminate concepts and appropriate mathematical language to facilitate understanding and communication. The idea that deep understanding of mathematical concepts is developed over time is held by the state and in the Montessori system of education, and both curriculums focus on highly interactive learning experiences that foster student thinking and understanding.

The state's requirement that mathematics programs should be appropriate to the maturity and developmental level of all students is reflected in the Montessori practice of individualizing instruction according to the child's needs, experiences, and ability level. The importance of allowing adequate time for completing substantial mathematical work is recognized by both approaches, and each program emphasizes repeated encounters with mathematical ideas in many different contexts. Problem solving ability is a priority of the state and in the Montessori curriculum, and the integration of mathematics with other school subjects, as well as integrating assessment and instruction, is encouraged by both approaches. While the *Mathematics Framework* openly states goals and expectations for student learning, in the elementary Montessori classroom similar desired outcomes remain unstated but are reflected in the curriculum's structure, content, and organization.

Both the state and Montessori approaches view the teacher as a facilitator and observer of student learning, and as responsible for establishing classrooms that are student-oriented, self-directed, and nonauthoritarian. Teachers in each system are expected to provide direct, hands-on learning experiences, rather than teaching through explanations, and mistakes, which should be found and corrected by the students themselves, are recognized by teachers in both approaches as a natural part of the learning process. Teachers are encouraged to question their students in the public school and Montessori system, and are expected to allow students to interact and work with one another on mathematical exercises and projects. In either program, teachers have high expectations for student work and achievement.

Most of the mathematical content of the state's elementary program, organized into general strands and unifying ideas, is also included in some capacity in the Montessori system of mathematics education. Conversely, most topics introduced in the Montessori

curriculum could be categorized under the strands and unifying ideas in the state's program of mathematics. The development of number sense is emphasized in both approaches and each program encourages the memorization of facts through the child's regular mathematical work and by fostering the belief that learning number facts can be beneficial.

Differences

Although similar in some respects, the California state and Montessori curriculums differ according to: (a) how content is organized, (b) the way an understanding of mathematical concepts is attained, (c) how instruction is given, and (d) in the type of work students are expected to complete.

Content Organization

The organization of content recommended by the *Mathematics Framework* differs considerably from the organizational structure of content in the Montessori mathematics curriculum. Mathematical content is described by the state in terms of strands and unifying ideas that provide depth and balance and are combined to form coherent instructional units. Each unit must incorporate several strands and one or more unifying ideas, and include a balanced mixture of interconnected tasks and assignments. Lessons within units should explore several interrelated mathematical ideas and their relationships, and help students to see how mathematics is integrated in their lives. The subject matter of a unit needs to be relevant for all students in their mathematics education, other academic work, or everyday experiences.

In the Montessori mathematics curriculum, content is organized into units or areas of study that introduce and develop individual mathematical concepts or ideas. Rather

than integrating content and emphasizing the connections between mathematical ideas, concepts are presented in isolation from one another. Within each unit of study, a particular concept is broken down into its component parts and presented in a progression of activities that move the child from concrete exploration of the idea in its simplest state to an abstract understanding of the concept in complex form. While the state approach considers strands as incomplete if they appear only one at a time and unifying ideas as too general and abstract to be the central focus of a study, the Montessori curriculum views isolating the component concepts found in the state's strands and unifying ideas as essential for building true understanding of mathematical ideas. The application and integration of mathematical ideas only occurs after the child has constructed her own knowledge of individual mathematical concepts and generally comes out of the child's own independent investigations.

Mathematical Understanding

How an understanding of mathematical concepts is attained also differs in the two approaches to mathematics education. In the state's mathematics curriculum, understanding is achieved by providing students with opportunities to use mathematics to make sense of their own experiences. Students are presented with numerous problem situations and develop their facility with mathematical ideas, as well as their ability to think, communicate, and use the tools and techniques of mathematics effectively, by exploring solutions and arriving at conclusions. Greater emphasis is placed on developing number sense than memorizing algorithms, and computational procedures are only introduced when needed by students within mathematical inquiries. Encountering mathematical ideas and concepts in many different interesting contexts builds the child's

understanding of mathematics and illustrates the variety of ways mathematical knowledge is useful.

In the Montessori system of education, understanding of mathematical concepts is systematically developed through a sequence of activities and materials that leads the child from sensorial exploration to abstraction by means of individual experience. Whereas the public school curriculum presents mathematical ideas within larger investigations and promotes the development of understanding through repeated exposure in meaningful contexts, the Montessori method builds understanding first using the graded materials and then encourages applying the skills in diverse situations. Computational procedures and algorithms are derived by the child herself through the use of material before an operation is needed in a broader application, and number sense is developed by determining whether answers are reasonable in relation to the facts of a given problem. A foundation for using the tools and techniques of mathematics is established through the variety of activities the child encounters, and thinking and communication are fostered by collaborative work and problem solving. The curriculum strives to assist the student in her total mental development while at the same time developing her mathematical reasoning and depth of understanding.

Instruction

While both curriculums recognize the value of using a variety of instructional modes in the teaching of mathematics, some aspects of how mathematics instruction is given in the state's curriculum are different from those used in the Montessori approach. Instruction in the state's system prepares students to complete specific tasks and projects. All students study the same core curriculum at the same time and direct, whole-group instruction and demonstrations are used to support the larger assignments. Students with

special talents or interests are encouraged to go more deeply into investigations, and those in need of supplemental assistance receive help outside of regular class time. Although students with similar interests and needs may be temporarily grouped together, tracking, or grouping students by ability, is not permissible within the state's mathematics curriculum.

Instruction in the Montessori mathematics program is individualized and provides a means for introducing concepts or exploring ideas at successively deeper levels of understanding. Rather than presenting information in a whole group setting, presentations are given to individual children or small groups and are geared toward helping children to progress at their own pace and level of ability. The mixed age groupings and high level of interaction between students in each Montessori classroom enables students to help and instruct one another and exposes younger children to the great variety of mathematical exercises available within the curriculum. Students receive assistance as needed, and mathematically gifted children have the freedom to explore ideas beyond the depth of assigned investigations. The continuity and flexibility of the curriculum from the preschool class through the elementary years makes individualized instruction possible and enables the teacher to cater to each child's interests, needs, and cognitive maturity.

The Work Students Do

The type of work completed by students in the state's mathematics curriculum also differs from the mathematical work undertaken by students in the Montessori method of education. In the state's system, students are assigned different types of work, including short exercises, collaborative tasks, and larger, long-lasting projects, and frequently work together. Many assignments are open-ended, allowing for a variety of solutions, and are

completed according to a comprehensive standard. Students use manipulatives and technology within assignments to explore mathematical concepts, model mathematical situations, and solve problems, and are asked to present the results of investigations orally and in writing. Assignments may take several days to complete and work that does not meet quality standards must be revised. The tasks and problems introduced must be meaningful, accessible to all students, and open enough to allow those interested to explore beyond the standard expectations. Students are expected to think and reason in all their mathematical work and to assume responsibility for their own learning.

In the Montessori elementary classroom, students choose the mathematical work they do and progress through the curriculum in their own manner. Rather than completing one unit of study before advancing to the next, Montessori children usually work with a variety of materials and in a number of different subject areas at any given time. Some students may prefer to work exclusively with one concept at a time while others may choose to vary from day to day the areas of work they explore. The manipulatives or materials used are closely linked together and provide a foundation for learning new mathematical ideas. The materials help children to discover concepts and procedures on their own and often allow for creative exploration and innovative follow-up activities. The built-in control-of-error in many of the materials encourages the completion of high quality work and enables the child to control her own learning situation. Technology, such as calculators and computers, has been integrated into most Montessori classrooms and is particularly evident at the upper elementary level where student initiated projects and investigations are common.

Conclusion

California's revitalized mathematics curriculum advocates complete program reform and an open-ended problem solving approach to mathematics instruction. The curriculum represents widespread consensus on how mathematics should be taught and reflects a move toward making mathematics interesting, relevant, and accessible to all students. However, the whole group format, prescribed curriculum requirements, and emphasis on building understanding through repeated encounters with mathematical ideas in different contexts may not be an effective means for responding to individual student's interests and needs. The individualized approach used in Montessori mathematics education accommodates students with diverse needs and interests, and establishes a foundation for mathematical problem solving. Early sensorial exposure during the child's sensitive period for mathematics and opportunities to construct mathematical understanding through specific materials and exercises distinguishes the Montessori approach from the state's, and has contributed to the programs continued success in developing mathematical ability and appreciation.

LANGUAGE ARTS CURRICULUM COMPARISON

The State English-Language Arts Curriculum

The *English-Language Arts Framework for California Public Schools, Kindergarten through Grade Twelve*, adopted by the California Board of Education in 1986, describes curriculum requirements for English-language arts programs within the state. Created by a committee of leading English and language arts educators, the document is meant to revitalize English-language arts instruction and encourage the design and implementation of an integrated literature-based curriculum for all students. The *English-Language Arts Framework* provides a philosophical direction for instruction and serves as a guide for teacher education, program evaluation, and the development of textbooks and instructional materials.

It is the intent of the *English-Language Arts Framework* to prepare all students to function as informed and effective citizens in our democratic society, to function effectively in the world of work, and to realize personal fulfillment. Recommendations included in the document are based on current developmental theory and research, and are geared toward reforming English-language arts instruction within the state. The framework identifies the following features in effective English-language arts programs and calls for:

1. A literature-based program that encourages reading and exposes all students, including those whose primary language is not English, to significant literary works.

2. Attention to values in literature that reflect the real dilemmas faced by all human beings and that represent traditional and modern classics across all the disciplines.
3. Instructional programs that emphasize the integration of listening, speaking, reading, and writing and the teaching of language skills in meaningful contexts.
4. Instructional programs that guide all students through a range of thinking processes as they study content and focus on aesthetic, ethical, and cultural issues.
5. A systematic kindergarten through grade twelve developmental language arts program articulated and implemented at all grade levels.
6. A writing program that includes attention to the various stages of the writing process--from prewriting through post writing and from fluency and content through form and correctness.
7. An oral language program in which all students experience a variety of speaking and listening activities, individual and group, integrated with reading and writing.
8. A phonics program taught in meaningful contexts, kept simple, and completed in the early grades.
9. A school environment where teachers of all subjects encourage students to read widely, to write frequently, and to listen and speak effectively.
10. A home environment where teachers, administrators, and other adults support the importance of language arts skills to the school program and model effective use of all language arts, including listening, speaking, reading, and writing.
11. Teacher preparation programs that provide candidates with: a broad background in literature; methods and processes of teaching language arts and

higher-order thinking skills in meaningful contexts; awareness of new research about how children learn; and resources offering help in design and implementation of language arts programs

12. An assessment program encompassing the full range of goals of the English-language arts program, aligned with what students are expected to learn in the English-language arts program, and providing alternate strategies and forms of testing.

English-language arts programs adopted by the state must be literature-based and integrate all the elements of language--listening, speaking, reading, and writing--in classroom instruction. Literature is incorporated into the curriculum through an in-depth study of core literary works, the reading of literature that extends the study of the core work, and recreational-motivational reading based on students' natural curiosity and that encourages them to read for pleasure. Students must have access to a wide variety of reading materials, including paperbacks, magazines, reference books, newspapers, and electronic media, to help them discover the magic of language and the limitless possibilities of learning. To help gain proficiency in each language process, the *English-Language Arts Framework* makes the following observations and recommendations:

Reading: Students learn to read by reading. Beginning readers should experience the excitement of understanding meaning in sentences before they are introduced to the more difficult task of identifying individual words. Basal readers should contain a rich assortment of child's classics, folk and fairy tales, and meaningful modern stories, and provide oral and written activity suggestions that can help teachers and students deepen their understanding of the literature.

Writing: Students learn to write by writing. Effective English-language arts programs offer students frequent practice in writing from their own experiences and from literature for a variety of purposes and audiences, both real and imaginary. Students must develop skill with all the stages of the writing process--prewriting, writing, sharing, revising, editing, and evaluating--and must develop a sense that something happens when writing is completed. Students should perceive themselves as writers and move from an initial focus on content to an emphasis on correctness in order to communicate effectively.

Oral Language Skills: Students must be provided with numerous opportunities to develop their listening and speaking skills in both structured and unstructured situations. Informal group discussions, role-playing, and decision-making as well as more formal speeches and presentations prepare students with the speaking and listening abilities necessary for learning and communicating. The development of proficiency in Standard English is an important goal for all students in the state today.

Role of the Teacher

Effective English-language arts programs require that teachers excite their students about learning to listen, speak, read, and write; incorporate knowledge about language acquisition and learning in their instruction; and demonstrate flexibility in their use of methods and in their attitudes. Teachers must help students to understand the significance of reading and writing in their lives and to find meaning in the language arts activities they encounter. Modeling enthusiasm for reading and writing encourages students to read and write themselves, while teachers who listen well help to develop good listening skills in their students. School wide programs of sustained silent reading

and forums that recognize student achievement in the language arts also emphasize the importance of developing language proficiency.

To help students understand why literature and language are important to us as human beings, they need to discover that real learning takes place through their own questioning and understanding of what ideas and answers mean to them. Questions enable students to focus their attention and move more easily to higher levels of expression and thought. Open-ended questions invite students to explore and to formulate their own questions leading to deeper learning and understanding.

Students benefit from instruction that explicitly teaches strategies for synthesizing and integrating information. The student should become the center of learning rather than the teacher, and be helped to discover how competent speakers, readers, writers, and listeners accomplish their ends in communicating with others. *The English-Language Arts Framework* requires that direct teaching strategies be adapted to individual students' needs and be applied in the teaching of the language processes in the following manner:

Reading: Students should discover the excitement of reading great literature. Teachers should apply strategies that help students approach the study of a text from pre-reading to beyond the encounter with the work, and to grasp its meaning in relation to their own lives and the world around them. Introducing students to a wide range of literature prepares them for understanding ideas and expressing themselves effectively about important human issues.

Writing: Direct teaching strategies should be employed to help students develop their composition skills. Assistance in generating and developing ideas, organizing details, and connecting ideas and paragraphs should be provided, and assignments

should lead students to better writing and critical thinking about themselves and the human condition.

Oral Language Skills: Direct instruction should help younger children to speak confidently and older students to speak effectively. Teachers should prepare students for oral reading and present strategies for developing effective discussion skills. Cultivating appropriate forms of speech should be an integral part of a student's school experience.

The Conventions of Language: Students frequently learn the mechanics of language intuitively while speaking, reading, listening, and writing. However, those skills not acquired must be taught directly so that the necessary conventions are learned. Instruction becomes more meaningful when mechanics and conventions are taught in context, such as when editing a classroom newspaper, then when isolated from any useful purpose.

The *English-Language Arts Framework* supports the integration of technology into the study of language and literature. Visual and audio media can introduce or supplement the study of literature while computers help students to develop writing, reading, and thinking skills. Technology must promote active engagement on the part of the student and software must tap the computer's full capabilities as an effective teaching and learning device.

Reaching each individual in a class of students with diverse needs, interests, talents, and backgrounds is the greatest challenge of teaching. Students with different predominant modes of learning must be accommodated through a range of teaching strategies, and students with special needs--those that are less-prepared, gifted, limited-

English-proficient, and special education students--require that teachers adapt their methods accordingly. Despite these considerations, the fundamentals of an English-language arts program remain constant: providing good literature; integrating instruction in all the language arts; encouraging extended reading in students' own areas of interest; and connecting English-language arts activities and materials with the students' own lives.

An effective classroom environment, according to the *English-Language Arts Framework*, is one in which the teacher and students expect that all students will become proficient in listening, speaking, reading, and writing in an atmosphere in which each student feels important and shares responsibility for the group. Language should be viewed as a social activity as well as a means for personal and individual discovery, and students must be provided with many opportunities to experience both independent and group work. Homework extends the student's language work into the family and should involve reading books of high literary quality and writing for enjoyment. The support of the home community in listening, speaking, reading, and writing ought to be extended to homework assignments whenever possible.

Program for Kindergarten Through Grade Three

The primary focus of all language activities for children in kindergarten through the third grade is the understanding that meaning is the first and most important reason for learning language. Language arts programs at this level must be integrated, purposeful, and constructive, and must be flexible in both pacing and content to accommodate the wide variation in readiness among young children entering school. Good literature should be read aloud daily and students should have many opportunities to speak and be heard. Early writing programs must introduce instruction in prewriting, drafting,

revising, and editing and the conventions of language should be taught as sub skills to meet the individual student's needs and as aids to the written communication process. Instruction in phonics should be included in the early years to assist the child in understanding meaning.

Program for Grades Three Through Six

Students between grades three and six become especially interested in the world beyond their immediate environment and understanding remains the greatest motivator for language learning. Reading activities must be meaningful and integrated with listening, speaking, and writing, and students continue to benefit from hearing literature read aloud daily, particularly when the material is at a reading level slightly above that of the students. Students at this level need many opportunities to speak formally to the whole group as well as informally with each other in small-group work and discussion. Students should write daily, and teachers can provide direct instruction of the strategies for good writing during the prewriting, drafting, revising, and editing stages. The conventions of usage should also be taught in meaningful contexts.

Program for Grades Six through Nine

Students begin to think more abstractly during the middle school years and can apply language skills with more sophistication as they develop a broader base of knowledge. Students can be helped to enjoy challenging literature by being read aloud to, and the student's own developing verbal and social skills should continue to be fostered through participation in discussions and various other activities that allow them to communicate orally. A school library and qualified librarian are essential for motivating students at this level, and students should experience a wide range of purposes for writing in both informal and formal assignments.

Assessment

Assessment of English-language arts programs must depend on tests that reflect the purposes of the revised curriculum. Tests will integrate all the language arts and focus on students' meaning, not on formalistic features such as plot and character. Good assessment will provide direction for the teacher and will be structured to evaluate students' strengths and accomplishments, not simply weaknesses or failures. Evaluation must include frequent informal assessment of students' responses to their own and their classmates' speaking, reading, and writing and the teacher's more formal evaluations of students' participation and responses and of individual and class progress toward objectives identified in the curriculum. A variety of assessment strategies should be used to provide teachers, students, and parents with a more accurate picture of students' facility with English-language arts.

Textbook and Instructional Materials Standards

The *English-Language Arts Framework* recognizes that basal textbook programs strongly influence the teaching of English-language arts in public elementary classrooms. A quality program will include a variety and balance of content with important literary works forming the program's core. The materials should integrate the elements of language, develop critical thinking skills in both the comprehending and composing processes of oral and written language, and introduce supporting skills and sub skills in context. Teacher's manuals should relate other content areas to language arts and language arts to other content areas, and provide several schedules and options for using materials with various ability levels and time allotments.

The Montessori Language Arts Curriculum

Language in the elementary Montessori classroom is connected to all curriculum areas and serves as a tool for exploration, communication, and self-expression by the elementary child. Language is viewed as the transmission of human thought and as a creative art form with both structure and beauty. Specific instruction in the English-language arts is only given to help the child use language more effectively and is tied to the development of language in its historical context. The elements of language become relevant to the child when they are given a foundation in history and when integrated into everything the child does within the classroom.

The elementary student is interested in exploring beyond the immediate environment and in knowing why things are the way they are. The Montessori language arts curriculum caters to these characteristics by enabling the child to investigate the origin and structure of words and the growth of language in relation to the development of culture. Irregularities in language, such as spelling difficulties, are examined from an historical perspective and can be better understood and remembered when the reason for the inconsistency is made clear. The student is shown how grammar and rules have been fashioned to make language a more usable tool, and is helped to realize that language is interesting because it is attached to life, not to grammar exercises contained in books. Language helps the child adapt to her culture and is viewed in the Montessori curriculum as a creation and expression of the human spirit and as a function of society that has changed over time.

The Early Childhood Language Arts Curriculum

A foundation for elementary language is established in the early childhood Montessori classroom. During the preschool years, language studies enable the child to develop and refine her communication skills with others while at the same time assisting the child in her total mental development. Self-expression in both spoken and written language is encouraged and the supportive environment fosters an interest and love for language related activities. All areas of the curriculum contribute to the child's language development and provide a means for the child to cultivate her communication skills on her own.

During the first six years of life the child is in a critical period for language acquisition and passes through stages of sensitivity that compel the child to interact with her environment in specific ways. The Montessori early childhood classroom is designed to cater to the child's sensitive periods for spoken language, writing, and reading through specific materials and a series of presentations that indirectly and directly prepare the child for the ability to read and write. Presentations, given to individual children or small groups, are short in duration and isolate one aspect of language in order to focus attention on that particular attribute. The child then has the option to continue with the activity or not. It is the child's interest, learning style, and general level of development and language abilities that shapes the curriculum each individual experiences (Chattin-McNichols, 1992).

Although the elements of language--speaking, listening, reading, writing, and grammar--are integrated in the Montessori early childhood language arts curriculum, specific activities can be grouped into the following categories for organizational purposes: (a) indirect preparation for language, (b) spoken language, (c) direct

preparation for reading and writing, (d) reading and writing, and (e) grammar. Through these experiences, the child is prepared for the advanced reading, writing, and grammar exercises she will encounter in the elementary Montessori classroom.

Indirect Preparation for Language

The preschool Montessori child is indirectly prepared for language studies through the practical life and sensorial activities within the classroom. The practical life exercises, which are activities of everyday life necessary for the care and maintenance of the self and the environment, help to refine the child's control of movement and hand and eye coordination necessary for writing. The left to right sequencing of the exercises prepare the child visually for reading, while frequent opportunities for conversation help to develop the child's speech producing abilities. The practical life exercises promote an understanding of the process and order involved in completing a cycle of activity and help the child to develop the concentration and inner discipline necessary for reading and writing.

Various sensorial materials, used to aid the intellectual development of the child through the refinement of the senses, indirectly prepare children for language studies by developing the muscles used in the process of writing and the perceptual abilities and visual and auditory discrimination necessary for reading and spoken language. Vocabulary enrichment is stressed with the sensorial exercises by connecting words, such as long, longer, longest, to particular materials and their attributes.

Other indirect preparation language exercises commonly found in Montessori early childhood classrooms include working with puzzles, various matching activities, and picture card material, often referred to as nomenclature cards or nomenclature material. Many of these activities require visual discrimination and help to develop small motor

coordination, the left to right sequencing pattern, a sense of order, and concentration. The nomenclature cards in particular help to expand the child's vocabulary, while all the indirect language activities prepare the child for reading and writing.

Spoken Language

Oral language in the primary Montessori classroom focuses on vocabulary enrichment activities and exercises that develop the child's speaking and listening abilities. Stories, poems, and rhymes are frequently read and told, and children are encouraged to participate in singing, dramatic play, and various naming activities and games. Sound recognition games, such as "I Spy", are introduced to help develop the child's ability to hear the beginning, end, and middle sounds of words and serve as preparation for associating sounds with their written symbols. These activities, combined with numerous opportunities for children to express themselves verbally in small group conversations or in informal chats with the teacher, help to build the child's skills and competency in listening and spoken language.

Direct Preparation for Reading and Writing

The Montessori preschool child is prepared directly for reading and writing through three sets of materials; the metal insets, the sandpaper letters, and the movable alphabet. The metal insets, which prepare the child's hand for writing, consist of red metal frames with blue insets of geometric shapes. By tracing around the inset and within the frame the child develops the muscles necessary for the act of writing while filling in the created shapes helps to foster the child's control of movement. The possibility of making creative designs with the insets motivates the child and allows a means for creative expression.

The sandpaper letters consist of letter shapes cut out of sandpaper and mounted on individual smooth boards. There is one sandpaper letter for each letter in the alphabet.

The young child is introduced to two or three letters at a time to help her associate a sound with its graphic symbol and to build muscular memory of the letter's shape. Once proficiency has been gained with the basic letter sounds, phonogram sandpaper letters are introduced to familiarize the child with sounds that require more than one letter. In this way, the sandpaper letters prepare the child both mentally for language and manually for written communication.

When the child is able to connect nine or ten sounds to their letter shapes, she is introduced to the movable alphabet. The moveable alphabet, usually made of cut out wooden letters, is used by the child to build words at a time when the physical act of writing has not yet been developed. By analyzing words into their component sounds, the child is able to compose words, and later phrases and sentences, using the movable alphabet to communicate his thoughts graphically. Eventually the child should discover that he is able to read back what he has written. Once this realization has taken place, the child is ready to move on to a series of reading exercises in preparation for simple book reading.

Reading and Writing

The phonetic object game is usually the first reading exercise the child is introduced to following the "discovery" of reading. In this activity, the child watches the teacher write a label and is then asked to match it with one of five or six different phonetically pronounced objects. Items in the environment and the classified picture cards can then be labeled, and simple puzzle words that are not phonetic can be presented to the child two at a time. Phrase and sentence reading can be introduced by matching a set of pictures with corresponding simple sentences written on slips of paper and through command cards which can be read and acted out by the child, individually or in a small group.

Phonograms can be introduced into these activities as appropriate and can be explored in more depth through phonogram lists and booklets that can be read and copied by the child.

Writing exercises run parallel with reading activities and could include various tracing activities, writing on black boards, and progressing from unlined paper to writing within lined spaces. The child should be encouraged to write creatively and to decorate and beautify her writing so that it becomes a source of pride and an enjoyable activity.

Grammar

Further reading opportunities are provided by the grammar or function of word exercises presented in the Montessori early childhood classroom. These exercises allow the child to explore how words relate to each other and to discover the function and usage of each part of speech. One function is introduced at a time, beginning with the noun, using a miniature environment model such as a farm. Each part of speech has a corresponding symbol that can be glued above the words in phrases or sentences to help reinforce the function of the words in the child's mind.

In the noun presentation the child is asked to state the naming words for various objects in the miniature environment model while the teacher writes the name for each on a slip of paper. The child may or may not be given the name noun at this point, depending on the teacher's preference, but would be introduced to the noun's symbol--a large black triangle. The written labels would then be lined up and a noun symbol would be placed over each. A variety of noun activities, including an introduction to singular and plural nouns, would then be made available to the child.

The child's exploration of the functions of words continues with an introduction to the article. Using the farm as the model environment, the concept of an article is

developed by directing the child to hand you a horse, a sheep, and the cow and then discussing that there was only one animal of the kind for *the* and more than one when *a* was used. A label that includes the stated article is written for each animal asked for and the article's symbol, a small blue triangle, is introduced. The child can then place the appropriate symbol over each word written on the labels.

Similar presentations and a variety of extension activities can be presented to the child for the adjective, verb, adverb, pronoun, interjection and conjunction. The importance of a word's position within a phrase or sentence is emphasized throughout these exercises.

The Elementary Language Arts Curriculum

Each section in the elementary Montessori Language arts curriculum has a developmental pattern that requires a knowledge of the introductory presentations for an understanding of the later work. However, rather than completing one unit before beginning another, work in all five sections continues at the same time with the beginning activities of each area of study forming a basis for all the language work initiated in the classroom. There are no specific age or grade levels given for any of the work and once a lesson has been presented the child may choose to continue on in the area or not. Different aspects of a subject may be taken up by different groups of students making it possible for the children to learn from one another. Five sections that can be used to organize the Montessori elementary language arts curriculum include: (a) history of language, (b) word study, (c) parts of speech, (d) sentence analysis, and (e) writing, spoken language, and literature.

History of Language

The study of language in the elementary Montessori classroom begins with an overview of the history of language. Two stories, *Communication in Signs* and *The History of Spoken Language* initiate the study, which is continued throughout the elementary years when various aspects of language development are then examined in detail.

The *Communications in Signs* story is presented first and explores the history of written language. It is given to arouse the child's interest and to link all the activities of language--speaking, writing, reading, imagination, research, individual and group work--together. Students are introduced to the various writing materials and implements that have been used over time and are encouraged to practice their own handwriting simultaneously with the story of the development of writing. A second form of writing, such as italics, can also be introduced at this time.

The *History of Spoken Language* story is presented after the history of written language has been explored and students have begun their practice in writing. Based on the premise that early man had thoughts he needed to share, the story explores theories of how spoken language may have begun. A history of the student's own language should be included in the study and the child should be made aware of how some of our spelling difficulties came to be. A good etymology dictionary should be made available within the classroom to aid the child in her exploration of language.

Word Study

Once a foundation for the study of language has been established through an overview of its history, the student can be introduced to the word study activities. The word study exercises explore suffixes, prefixes, compound words, and word families and

help to maintain the child's interest in language by connecting grammar to the study of the origin of words. The activities are an aid to spelling and help to extend the child's vocabulary and understanding of word structure.

Suffixes are introduced using two small movable alphabets of different colors and a wall chart divided into columns that contain three words--a root word, the same root with a suffix, and the same root with a different suffix. Using one of the movable alphabets, the student is asked to lay out one of the columns and then to exchange the suffix letters with letters from a different colored alphabet after the concept of a suffix has been introduced. The child can continue by laying out other columns and writing the words on paper and can be introduced to the term root to describe the portion that each of the three words has in common. Prefixes can then be explored in the same manner using a black movable alphabet for the root in each word.

Compound words are introduced using a collection of boxes to illustrate that the second word tells the name and the first word, the kind. Children continue to work with compounds using a wall chart containing compound words, the movable alphabet, and black and colored inks or pencils for writing the words out. Simple compound words are introduced at the lower elementary level while obscure or latent compounds, such as barn from barley and hall, can be given to an older student to encourage the research of others like it.

Word families are explored after the child has learned the different parts of speech also using charts, the movable alphabets, and colored pencils or inks. Various activities help the student to become aware that words contained in the same family all have something to do with one another.

Grammar

The grammar portion of the Montessori language arts curriculum can be divided into three sections: (a) parts of speech, (b) the verb, and (c) sentence analysis. Students may work in all three areas concurrently.

Parts of Speech

The elementary child continues her exploration of the parts of speech started in the primary classroom through a material called the grammar boxes. The grammar box material consists of a collection of compartmented grammar boxes, one for each part of speech (except the noun); a set of filler boxes for each part of speech containing written material to be used with the corresponding grammar box; and command cards which are read and acted out by the child. Each set of boxes is classified by color and isolates a different part of speech by only adding one new function to those that have already been introduced. The parts of speech are introduced in order--noun, article, adjective, verb, preposition, adverb, pronoun, conjunction, interjection--and every time a new part of speech is presented, another slot is added to the end of the grammar box.

Each part of speech is investigated through a sequence of exercises beginning with a lesson that includes one or more oral commands which when acted out by the child should give an impression of that particular part of speech. For example, to help children understand the concept of a noun they are asked to look around the room, at length, for something that does not have a name. After the initial introduction, the grammar box is presented to a small group of children. This work involves the children in reading a phrase or sentence card from a filler box, reproducing the phrase or sentence with individual cards, and placing the correct grammar symbol over each word. Once the verb

has been introduced, children can experiment with changing the sentence's word order to determine how placement affects the meaning of the sentence.

Each separate card is then placed in the appropriate slot in the grammar box and the child is introduced to the name of the new part of speech that has been presented. The filler boxes for that particular function then provide a series of classification exercises for the child and the corresponding command cards can be used to provide repetition and practice in reading comprehension and opportunities for group discussion and debate. A variety of follow-up activities can be initiated as appropriate.

In order to maintain the student's interest in this work, the grammar boxes must be completed at the lower elementary level, preferably by the time the child is eight. The exercises are intended to interest the child in words, not to teach grammar, and should lead to work in grammar books during the upper elementary years. It is also the intent of the grammar box activities to help the child write more clearly and effectively. The following is a summary of the scope and sequence of the Montessori grammar box exercises:

The Noun and Article

Introduction to the Noun

Introduction to the Article

Definite and Indefinite Article

The Noun: Number

The Noun: Gender

Classification of Nouns

The Adjective

Introduction to the Adjective

Comparison of Adjectives

Classification of the Adjective

The Verb

Introduction to the Verb

Synonyms

The Preposition

The Adverb

The Pronoun

The Conjunction

The Interjection

The Verb

The child's work with the grammar boxes is supplemented with a series of lessons on verbs once the initial verb presentation has been given. Various sets of card materials are used to examine different qualities of the verb and the verb's history in old English is explored by the upper elementary student. Areas of exploration include:

Simple Tenses of the Verb

Weak and Strong Verbs

Introduction to the Packets

Auxiliary Verbs

Compound Tenses of the Verb

Moods of the Verb

Voices of the Verb

The Negative Form of the Verb

Sentence Analysis

The sentence analysis exercises introduced in the Montessori elementary classroom help the student to learn the basic parts of a sentence, i.e. the subject, predicate, direct object, indirect objects, clauses, etc. They familiarize the child with different types of sentences and lead her to a deeper understanding of how the elements of a sentence relate to one another. The logical order inherent in the English language is emphasized by using the material and the student is helped to evaluate what she has read and to express her own thoughts more clearly in writing.

The sentence analysis material enables the student to do a form of three-dimensional sentence diagramming and is composed primarily of wooden arrows with questions written on them and different sized circles in various colors. To use the material, the child dissects a sentence that has been written on a slip of paper and uses the questions written on the arrows as a guide for determining on which circles the segments of paper should be placed. Once all the parts of the sentence have been placed, the arrows can be turned over to reveal the name of the part of the sentence that the arrow is pointing to. As the child begins to internalize the component parts of a sentence, the material becomes more abstract and more complex sentences are introduced. By the end of the elementary years, the student will have worked through all the exercises, which include the following:

Logical Analysis of Simple Sentences

Predicate, Subject and Direct Object

Indirect Object

Adverbial Extensions

Attributive Extensions

Transitive and Intransitive Verbs**Verbal and Nominal Predicates****Elliptical Sentences****Direct and Inverted Order****Active, Passive and Reflexive Voice****Compound Sentences**

Oral Introduction

Adjectival Clauses

Adverbial Clauses

Negative Form of the Verb

Noun Clauses

Correlative Sentences**Compound and Complex Sentences****Writing, Spoken Language, and Literature*****Writing***

By the time the child reaches the elementary level, the use of specific material to help develop the ability to write will have been completed. The sand paper letters and movable alphabet will have prepared the student mentally for composing words and sentences while the metal insets will have made it possible for the child to control a writing instrument. Now the child must be helped to write with skill and style both factually and creatively. The elementary Montessori teacher can help the child with this process by serving as an example for writing by writing herself in the classroom and by developing writing programs in accordance with the following guidelines.

The child is prepared for writing creatively by hearing and reading a wide range of quality literature. The work of many different authors should be introduced as well as literature from the child's own heritage. Students should be encouraged to discuss the books they've heard and read and can be helped to begin writing creatively by composing group stories, telling or writing back stories they've been told, or writing a story with the teacher by alternately writing sentences. Errors in the child's early writing should not be changed but noted and taken care of through other work. Older students should be encouraged to write a rough draft that can later be corrected and refined.

In order to write factually, the child must be shown how to find and record information. The student needs to learn how to identify key words while note taking as well as how to write the information obtained in her own words. She needs to be taught how to use the library and can be given the story of Dewey and the system he developed to help her remember how the library is set up. Throughout the process, the students should be made aware that they are not writing for the sake of writing, but because they want to share something, keep a record for themselves or others, or merely for the joy of writing.

The child's completed written work can then be exhibited in a variety of ways--booklets, scrolls, posters, time lines--and should be decorated, illustrated, and embellished in order to be made more beautiful. Examples of elegant writing from the past can be shown to the children to encourage them to perfect their own handwriting, and italic writing and the use of colored inks can be introduced to further motivate the student to develop her manual writing ability.

The student's elementary writing may take the form of factual writing, reports, imaginative stories, letter writing, dialogues, descriptive writing, plays, and poetry. Group or individual writing should occur in all subject areas and students should choose

their own topics based on ideas they have come up with themselves or on suggestions given by the teacher. Student's should be given information on ways to improve their writing style and should be helped with spelling, grammar, and punctuation as necessary.

Spoken Language

Spoken language is a vital part of the Montessori elementary program signifying that the classroom is an active, living environment where the exchange of ideas is highly valued and encouraged. Children are free to discuss their work with one another and are also allowed to talk about things other than academics as long as they themselves are able to keep up with their work. In addition to frequent informal conversations, elementary Montessori students develop their spoken language abilities by verbally presenting reports in class and by participating in debates, spoken dialogue exercises, and drama activities.

Literature

During the elementary years, the child should be exposed to a great variety of literature including rhyme, verse, poetry, biographies, letters, and antidotes. Literature in the elementary classroom should be related to grammar, treated through the study of style, and viewed from an historical perspective to help provide the child with a background for what she is reading. The child should have access to a public library and a sampling of literature should be kept in the classroom to introduce the child to a variety of material. Children can be read to during arts and crafts activities, and listening to the readings at this time should be made optional. Literature should be used to help bring children to the point where they understand the feeling of what has been written rather than just comprehending each word, groupings of words, or the grammatical expression

of the author. The student's study of literature can also include children's literature and can involve the child in creating time lines of writers or writing their own biographies.

The State and Montessori Language Arts Curriculums Compared

The *English-Language Arts Framework* describes the goals, principles, and practices of a literature-based language-arts program that emphasizes the integration of listening, speaking, writing, and reading and the teaching of language skills in meaningful contexts. The Montessori elementary language curriculum also recognizes the importance of a holistic approach to language arts education and has many features in common with the state's guidelines for curricular development. These include the teacher's role in language arts instruction and similarities in theory and organization.

Similarities

Teachers in both systems are expected to incorporate knowledge about language acquisition and learning in their instruction and should cater to different learning styles and needs by adapting an extensive range of teaching strategies. A positive climate for learning should be established by teachers in each approach and both advocate allowing students to work independently and cooperatively. Both the state and Montessori curriculums emphasize that the learner, rather than the teacher, should become the center of education and that students should be allowed to take an active role in their own learning. The importance of having high expectations for student learning and teachers modeling reading, writing, and listening is recognized in each language arts program. The daily reading aloud of quality literature from many nations and perspectives is also advocated by each approach.

Both curriculums recognize the significance of understanding meaning as the reason for learning language and view the desire to communicate as an essential motivational factor for learning language skills. Integrating the elements of language and teaching skills in meaningful contexts is stressed in both approaches, and each system advocates encouraging students to read, write, listen, and speak in all subject areas in the classroom. Helping students to discover how good listeners, speakers, readers, and writers have accomplished their ends in communication with others is promoted in each curriculum and both systems emphasize learning to read and write by reading and writing. Both approaches encourage recreational reading and hold the view that early language arts programs should provide for flexibility in pacing and content.

The state's requirement that instructional programs should guide students through a range of thinking processes as they study content is applied in the Montessori system, as is the state's recommendation that students participate in meaningful and interesting word studies. Both curriculums also share the belief that students should be exposed to classical and contemporary literary selections as well as a variety of expository writing. Continuity from year to year is valued in both approaches.

Differences

Both the public school and Montessori elementary language arts curriculums differ significantly from traditional skill-based programs that emphasize phonetics, controlled vocabularies, and the isolation of the language processes in instruction. There are also many similarities between the state and Montessori method in how language arts education should be approached and implemented. However, some aspects of the state's approach including: (a) how content is organized, (b) how instruction is given, and

(c) the way that beginning reading and writing skills are developed, are different from the methods used in Montessori education.

Content Organization

Although both the state and Montessori curriculums emphasize a holistic approach to the study of language arts, they differ as to how content is organized and integrated. In the state's approach, the processes of reading, writing, listening, and speaking are interwoven in activities that support the study of a work of literature. Direct teaching strategies in each area are used within the context of exploring literature and exercises that interrelate the elements of language are used to help deepen the child's understanding of a literary selection. The conventions of language, such as spelling, grammar, and vocabulary, are integrated within the total language program rather than taught in isolation and are presented as needed to aid communication. Organizing content around the study of literature stimulates student interest in language learning and provides a format for integrating language instruction.

Whereas the state language arts curriculum is literature-based and integrated through the study of core literary works, the elementary Montessori language arts curriculum is connected to the historical development of language and to all other subject areas explored in the classroom. Reading, writing, listening, and speaking are interrelated in the introduction and use of concrete language materials as well as through the child's self-initiated research projects. Unlike the state curriculum, which recommends against the isolation of language skills, the Montessori approach uses key exercises that isolate a single concept or idea in order to provide a foundation for understanding language and to enable students to cultivate their own communication abilities. Individually chosen activities, either within or outside of the prepared language

arts curriculum, motivate students to learn and apply language skills, and ensure that the reading, writing, and oral language activities children engage in are meaningful, interrelated, and connected to their own experiences. While the reading of quality literature is important in the Montessori method, it does not form the basis for language learning or for integrating the language curriculum.

Instruction

How instruction is given in California's English-language arts curriculum is also different from the way children are instructed in the Montessori approach to language arts education. The state's curriculum is textbook based and provides all students with a common cultural background through the study of core literary works. The direct teaching of language skills is emphasized and students are assigned reading, writing, and oral language tasks in relation to their exploration of literature or within other meaningful contexts. Helping students to understand meaning in the language exercises they encounter is the primary focus of instruction in the state's approach and teachers are encouraged to actively involve students in their own language learning. A whole group orientation toward instruction is suggested throughout the *English-Language Arts Framework* and no mention of individualized or small group instruction is made within the document.

Instruction in the Montessori language arts curriculum is individualized and provides students with opportunities for developing an understanding of their language and its usage. Whereas the state uses textbooks and direct teaching strategies in language instruction, the Montessori method focuses instruction on the presentation of manipulative language materials that enable students to explore concepts, clarify ideas, and progress at their own pace and level of ability. Stimulating lessons in other

curriculum areas and self-chosen projects, rather than the sequential study of pre-selected literary works, motivate students to seek information and to learn the skills necessary for effective communication. Literature and other print material are read according to the child's interests, and language skills are acquired as needed to complete self-initiated research projects. Long periods of unstructured and uninterrupted class time enable students to read, write, and discuss their work freely and to receive help as needed on an individual bases.

Reading and Writing

California's *English-Language Arts Framework* does not outline or recommend a specific program for teaching beginning reading and writing within the state's schools. However, the document does describe some practices that suggest an approach toward early reading and writing instruction that differs considerably from the method used in Montessori education. In the state's system, basal textbooks are used to introduce even beginning readers to a variety of quality literature. Decoding skills are taught to help children identify individual words and the understanding of meaning is emphasized in all reading activities. Writing instruction provides students with frequent practice in writing about a wide range of subjects, and early writing programs are required to include instruction in prewriting, drafting, revising, and editing. Learning to read by reading and to write by writing is emphasized throughout the *English-Language Arts Framework*.

In the Montessori system, children systematically attain the skills necessary for reading and writing during the preschool years when language learning is easy and comes naturally to the child. Sound recognition exercises and concrete materials develop the child's ability to associate a sound with its graphic symbol, which in turn prepares the child for writing with the movable alphabet. Reading occurs when the child discovers

that she can read back what she has written. Subsequent reading activities develop the child's decoding skills and sight vocabulary, and gradually prepare her for book reading. Writing exercises provide opportunities for handwriting refinement and creative expression, and initially emphasize the process, rather than the mechanics, of writing. The grammar and word study activities at the elementary level, and numerous opportunities for independent reading and writing, continue to develop the child's ability to compose and comprehend. The skills necessary for beginning reading and writing are developed prior to, rather than during, the process of reading and writing, and understanding of meaning is fostered by connecting reading and writing to the child's own words and self-initiated projects.

Conclusion

Reform in California's English-language arts curriculum has focused on integrating the elements of language in a meaning-centered literature-based program. Quality literature motivates students to learn language, and essential skills, including learning to read and write, are taught through direct instruction within meaningful contexts. In the Montessori approach, language learning is individualized, connected to the child's interests, and developed through concrete materials and sequential activities. Prerequisite language skills are systematically developed prior to beginning reading and writing and learning language as a means for communication is emphasized. Although both approaches provide a context for acquiring language ability, the Montessori method accommodates individual interests and needs, and is fully integrated into the total elementary curriculum.

DISCUSSION AND CONCLUSION

This paper has explored the theoretical bases of the Montessori elementary curriculum, reviewed Montessori research, and compared California's revised mathematics, science, history-social science, and English-language arts curriculums with comparable subject areas in the Montessori approach to elementary education. The Montessori elementary curriculum was shown to reflect a cognitive view of mental development with some behaviorist characteristics, and research on the method indicated that the approach is beneficial to children's cognitive, academic, and social development.

There were many areas of theoretical agreement between the state and the Montessori method in all four curriculums. These included each subject's emphasis on: (a) actively involving students in the learning process, (b) relating materials and activities to real experiences and student's own lives and interests, (c) motivating students to learn through meaningful activities, (d) developing critical thinking skills, (e) meeting every student's needs, (f) integrating each discipline with other school subjects, (g) providing opportunities for both independent and group work, (h) using a wide range of teaching strategies, (i) developing depth of understanding, and (j) completing in-depth projects.

There were also areas of difference between the state and Montessori approach in all four academic subjects. These focused on what content was included, when it was introduced, and how it was presented. The state system distributed content by grade level, was primarily textbook based, and focused on the attainment of the skills and knowledge in each subject area that are necessary for functioning as responsible citizens. In the Montessori approach, individual student's needs, interests, experiences, and abilities determined when and what content was introduced; content was explored in

concrete materials and diverse resources, rather than textbooks; and assisting the child in her mental development was a primary goal of the method. Whereas the state curriculum delegated the responsibility for making content meaningful, interesting, and related to student's lives and experiences to instructional material publishers, the Montessori approach met these criteria by focusing on self-chosen activities and relating content to the psychological characteristics and developmental needs of the child.

While there is substantial theoretical agreement between the public school and Montessori curriculums on what should be emphasized to create a successful educational program at the elementary level, there is significant difference in the methods used by each approach to accomplish this end. One possible reason for this disparity lies in the educational aim of each approach. Whereas the state emphasizes the acquisition of skills and knowledge, the Montessori approach focuses on the holistic development of the child. Another contributing factor is the state's lack of a unifying element to truly integrate the curriculum. Cosmic education in the Montessori system holds the curriculum together throughout the elementary years and establishes a framework for interrelating subjects, organizing knowledge, and accommodating individual learning differences. A third consideration is the Montessori method's use of sensitive periods to maximize the child's learning potential. Beginning the child's education at the early childhood level in a developmentally appropriate environment with freedom of choice makes it possible to capitalize on the child's natural learning abilities and prepares the child to handle a more challenging curriculum at the elementary level. By focusing on development, taking advantage of children's sensitive periods, and uniting the curriculum through cosmic education, the Montessori system has a means for implementing an educational program geared toward how children learn. It is unlikely that the state's elementary curriculum, with its prearranged content, separate subject orientation, and

emphasis on learning, rather than development, will result in educational applications that are as consistently learning appropriate as the Montessori approach.

Conclusion

The Montessori system of education represents a coherent alternative to traditional educational practices in the state of California. The elementary curriculum is in line with contemporary views of intellectual development and embodies instructional practices that are consistent with California's educational reform efforts. The application of the approach in the public sector could profoundly influence the quality of education within the state.

REFERENCES

- Baines, H. R., & Snortum, J. R. (1973). A time-sampling analysis of Montessori versus traditional classroom interaction. Journal of Educational Research, 66, 313-316.
- Banta, T. J. (1969). The Montessori research project: Four progress reports. American Montessori Society Bulletin, 7(1), 1-16.
- Banta, T. J. (1970). Research on Montessori and the disadvantaged. In R.J. Orem (Ed.) Montessori and the special child (p. 171-178). New York: G. Putman.
- Banta, T. J. (1968). The Sands School project: First-year results. (ERIC Document Reproduction Service No. ED 054 870).
- Berk, L. (1973). An analysis of activities in preschool settings. Final Report. Washington, D.C.: National Center for Educational Research and Development.
- Berger, B. (1969). A longitudinal investigation of Montessori and traditional prekindergarten training with inner city children: A comparative assessment of learning outcomes: Three part study. New York: Center for Urban Education. (ERIC Document Reproduction Service No.1 ED 034 588)
- Berger, B. (1970). An investigation of Montessori versus conventional prekindergarten training with inner city children: An assessment of learning outcomes. American Montessori Society Bulletin, 8(2), 1-10.
- Boehnlein, M. (1988). Montessori research: Analysis in retrospect. Cleveland: The North American Montessori Teacher's Association.
- Bronstein, M. & Bruner, J. (1989). Interaction in human development. Hillsdale, N.J.: Lawrence Erlbaum Associates, Publishers.
- Bruner, J. (1978). The process of education. Cambridge: Harvard University Press.
- Chattin-McNichols, J. (1983). Montessori in the public schools: Steady growth. The Constructive Triangle. 10, 20-21.
- Chattin-McNichols, J. (1992). The Montessori controversy. Seattle: Seattle University & the Montessori Education Institute of the Pacific Northwest.
- DeJong, C. (1985). A comparison of Montessori and public school CTBS scores. The Constructive Triangle. 12(3), 23-24.

- DeVries, R. & Kohlberg, L. (1987). Programs of early education. New York: Longman.
- Duax, T. (1989). Priliminary report on the educationally effectiveness of a Montessori school in the public sector. The NAMTA Journal, 14(2), 56-62.
- Ellis, A. (1991). Teaching and learning: Elementary social studies. Massachusetts: Allyn and Bacon.
- Flynn, T. (1990). Development of social, personal and cognitive skills of preschool children in Montessori and Traditional preschool programs. (ERIC Document Reproduction Service No.1 ED 337 297).
- Furth, H. (1970). Piaget for teachers. Englewood Cliffs, N.J.: Prentice-Hall, Inc.
- It's Elementary. (1992). Sacramento, CA: California Department of Education.
- Kahn, D. (1990). Implementing Montessori education in the public sector. Cleveland: The North American Montessori Teacher's Association.
- Kahn, D. (1993). Montessori in the public schools: Implementation basics. Cleveland: Montessori Public School Consortium.
- Kohlberg, L. & Mayer, R. (1972). Development as the aim of education. Harvard Educational Review. 42, (4).
- Glenn, C. (1989). A comparison of lower and upper elementary Montessori students with a public school sample. The NAMTA Journal, 14(2), 63-68.
- Gross, R. B., Green, B. L., & Clapp, D. F. (1970). The Sands School project: Third year results. Cincinnati: University of Cincinnati Department of Psychiatry, College of Medicine.
- Guidubaldi, J., Bersani, C., Kehle, T. & Sexton, S. (1974). Effectiveness of preschool programs as a function of children's socioeconomic status. Paper presented at the American Educational Research Association annual meeting. Chicago: Illinois.
- Karnes, M., Teska, J., & Hodgins, A. (1970). The effects of four classroom interventions on the intellectual and and language development of 4-year-old children. American Journal of Orthopsychiatry, 40(1), 58-76.
- Karnes, M. (1978). The 1965 preschool study and follow-up through the third grade.

- LeFrancois, G. (1982). Psychology for teaching. Belmont, California: Wadsworth Publishing Co.
- Lillard, P. P. (1996). Montessori today: A comprehensive approach to education from birth to childhood. New York: Schocken Books.
- Miller, L. & Bizzell, R. (1983). Long-term effect of four preschool programs: Sixth, Seventh, and eighth grades. Child Development, 54, 727-741.
- Miller, L. & Bizzell, R. (1984). Long-term effects of four preschool programs: Ninth- and tenth-grade results. Child Development, 55, 1570-1587.
- Miller, L. & Dyer J. (1975). Four preschool programs: Their dimensions and effects. Monographs of the Society for Research in Child Development. 40(5-6), 1-170.
- Montessori, M. (1964). The Montessori method. New York: Schocken Books.
- Montessori, M. (1973a). To educate the human potential. India: Kalakshetra Publications.
- Montessori, M. (19973b). The secret of childhood. New York: Ballentine, Books.
- Montessori, M. (1978). The formation of man. Trans. A.M. Josten. India: Kalakshetra Publications.
- Murphy, M. & Goldner, R. (1976). Effects of teaching orientation on social interaction in nursery school. Journal of Educational Psychology, 68, 725-728.
- Piaget, J. (1970). Science of Education and the psychology of the child. New York: Grossman Publishers, Inc.
- Reich. C. (1974). Follow-up of the Montessori Programme. Ontario, Canada: Toronto Board of Education.
- Rowher, W., Ammon, P. & Cramer, P. (1974). Understanding intellectual development: Three approaches to theory and practice. Hinsdale, Illinois: Dryden Press.
- Reuter, J. & Yunik, G. (1973). Social interactions in nursery schools. Developmental Psychology, 9, 319-325.
- Schweinhart, L., Weikart, D. & Larner, M. (1986). Consequences of three preschool curriculum models through age 15. Early Childhood Research Quarterly. 1, 15-45.

- Seefeldt, C. (1977). Montessori and responsive environment models: A longitudinal study of two preschool programs, Phase two. Paper presented at the annual meeting of the American Education Research Association, New York.
- Staskey, P. & Chester, B. (1988). Now we have some idea: Achievement tests and self-esteem in Montessori school graduates. The Constructive Triangle. 15(2), 4-8.
- Stodolsky S. & Karlson, A. L. (1972). Differential outcomes of a Montessori curriculum. Elementary School Journal, 8, 419-433.
- Taba, H. (1962). Curriculum development: Theory and practice. New York: Harcourt Brace Jovanovich.
- Takacs, C. & Clifford, A. (1988). Performance of Montessori graduates in public school classrooms. The NAMTA Journal, 14(1), 1-9.
- Toll, S. (1976). Evaluation of the prekindergarten Head Start: Year end report, 1975-1976 (Report No. 7700). Philadelphia School District, Pennsylvania: Office of Research and Evaluation.
- Villegas, A. M. (1989). Two sample case studies. In D. Kahn (Ed.), Implementing Montessori education in the public sector (pp. 469-475). Cleveland: The North American Montessori Teacher's Association.
- Villegas, A. M. (1988). The socialization of children in a Montessori classroom. In D. Kahn (Ed.), Implementing Montessori education in the public sector (pp.458-467). Cleveland: The North American Montessori Teacher's Association.
- Wadsworth, B. (1978). Piaget for the classroom teacher. New York: Longman Inc.
- Wadsworth, B. (1989). Piaget's theory of cognitive and affective development. New York: Longman, Inc.
- Wexley, K., Guidubaldi, J., & Kehle, T. (1974). An evaluation of Montessori and day care programs for disadvantaged children. The Journal of Educational Research. 68, 95-99.