A Comparison of a Math-Center and a Traditional Program in Mathematics with First Grade Pupils in the Roosevelt Elementary School

Barbara Jean Knecht Eldredge

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A COMPARISON OF A MATH-CENTER AND A TRADITIONAL PROGRAM IN MATHEMATICS WITH FIRST GRADE PUPILS IN THE ROOSEVELT ELEMENTARY SCHOOL

by

Barbara Jean Knecht Eldredge

A seminar report submitted in partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION

in

Special Education

UTAH STATE UNIVERSITY
Logan, Utah

1973
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The phone rang at the home of the principal the evening of the first day of school. The voice on the telephone said, "I must talk with you--tonight!" The principal arranged an appointment for 7:30 that evening in his office at the school.

The pistol the man wore at his hip was removed by the police officer who confronted him at the door of the school building. The officer had responded to an earlier report that the life of the principal had been threatened by this father. The policeman remained nearby throughout the interview.

The principal explained that upon the recommendation of his son's kindergarten teacher and considering the scores obtained from formal readiness assessments it had been decided to place the boy in a transitional first grade where he could receive the special attention and individualized curriculum he needed in order that he not become a first grade "drop-out" or retention.

The father responded by saying that he would keep his son out of school rather than let him attend that special class. "Why is this the only class where his needs can be met? Why aren't all teachers meeting individual needs? What proof do you have that my son will really learn in this
room without textbooks and where each child is studying something different?"

In preparation for the new school year a fifth grade teacher approached her principal, "Sir, as I look at the students I have in my fifth grade this year and realize the vast range of abilities which exist within the group, I feel that I cannot effectively teach them if I must work from the traditional textbook approach. They need a more individualized situation. I have been doing a great deal of reading lately about open education and learning centers and I would like your support for the organization of my classroom based upon the concept of open education."

"Mrs. Teacher, do you mean to say that you really want to try this open education idea?! We have to be careful about trying new things like that! Don't you realize that we already have one new program starting in our school this year? I wouldn't dare attempt any other new program until we see how the parents react to this programmed reading! Besides, can you show me that children can really learn in this open education arrangement? It looks like a lot of confusion to me. How can children acquire skills without the organization provided by a textbook? Why, textbook authors are recognized authorities in their field! I haven't seen any research that indicates that these new programs are successful. How could I possibly justify this change to parents without research to support it. No, I don't think that I could grant you in this request."
How to research? How to find justification?

Change meets opposition—professional as well as non-professional.

Therefore, the writer proposes this study in an effort to compare the effectiveness of an "open" interest-center approach aimed at meeting the individual needs and interests of students with the effectiveness of a traditional teaching approach being used in the same school to obtain data for justification.

Actually, there has been much research recently which verifies the need for an individualized curriculum. And the earlier in his life a child receives this individualization the greater the growth possibilities. Research by Bloom (1964) has indicated that a child will have developed to approximately fifty percent of his adult intelligence by the age of four, with another thirty percent coming by eight years of age.

Researchers at the Gesell Institute have also found that a significant change of intelligence can be derived through an enriched environment during early childhood.

Incorporating these statements with Piaget’s statement: "The more things a child has seen and heard, the more he wants to see and hear," (Furth, 1970), it seems reasonable to assume that the desire and ability of a child to learn can be dramatically changed prior to the age of eight through proper arrangement of his environment, particularly for children who have learning disabilities.
Gesell Institute reports: "Much of the misery today on the college level is produced through pressures and false hopes of the parents in regard to their child's potential for success" (Pines, 1967). This is true for children with learning disabilities and for the gifted, heretofore, unchallenged students. These pressures begin mounting during early childhood and greatly affect learning.

Allowing immature children to enter a traditional first grade, believing that they will "outgrow" their difficulties, is a procedure fraught with hazards. These first graders do not naturally catch up but, instead, they tend to fall further behind (Pines, 1967).

When boys and girls struggle with school work for which they are not developmentally suited they feel failure even in these primary grades. However, these learning disabled children can often achieve the minimum and thereby warrant promotion.

As they struggle through school, unable to meet the academic challenge, their self-concept becomes steadily more negative. On the other hand, the more able student meets similar frustration as a result of no real intellectual challenge. He develops poor study habits and poor attitude as he realizes the inappropriateness of his class assignments to his educational and intellectual needs.

The late Dr. Gesell of Yale Clinic of Child Development stated:

We know that all infants do not creep, walk or talk at the same time. But forget this and assume
incorrectly that by reaching a certain birthday a child should automatically become ready for the work of a certain school grade. (Tyler, 1967).

Individual differences in physical, intellectual, and behavioral development add greatly to existing chronological age differences when learning experiences are being considered.

No child should be curtailed by any organizational barriers, and provisions should be made for every child to learn according to his own growth patterns. Educators are having little influence upon the traditional chronological age requirement for public school entrance. However, there are many things which can be done in organizational, as well as teaching techniques, which will meet the developmental needs of each child.

Jean Piaget, the Swiss psychologist, who has been studying the intellectual development of children for fifty years, indicates that the ability to think and to learn is itself a growing thing and is therefore cultivatable by proper "preparation of the seed bed." Piaget's painstaking studies of growing children have given us new conceptions of the way thinking grows.

Curriculums should be adapted to benefit growth patterns of each child's thought process. Every child should be permitted the opportunity to progress with satisfaction at his optimum rate.

As more emphasis is being placed upon the necessity of meeting individual needs of children in the classroom, educators are seeking innovative ways to achieve this goal.
Open structure, which includes the integrated day, discovery center, and learning center, is the result of such educational innovation. Like other educational designs, the open structure plan of individualization can be described in terms of elements of a model-framework, such as this one developed by Tyler (1968) and others:

**Outcomes:** Basic goal is the development of self-actualizing, autonomous individuals.

**Learning opportunities:** Varied, Field trips, discussions, audio-visual aids and texts. Opportunities selected in terms of learning styles.

**Method:** Some didactic method but mostly inquiry approach.

**Knowledge:** Knowledge is viewed as existing in terms of its methods of inquiry.

**Nature of Role of Teacher:** The teacher participates in decisions about ends and means. The teacher also provides resources. (The teacher stimulates, guides, clarifies, helps to facilitate and supports.)

**Organization:** Nongraded. Various grouping patterns.

**Evaluation:** All outcomes are assessed. There is system as well as self-evaluation.

**Nature and role of learner:** The learner is active and autonomous. He participates in decisions about ends and means and carries the responsibility for learning. (Darrow, 1968)

Opponents to open structure claim that learning cannot be effected in such an unstructured setting, and that students placed in such a setting will not acquire the skills necessary for further educational advancement. They
contend that a graded traditional classroom is the most effective method of teaching children.

It is recognized that the entire curriculum needs to be individualized but for the purposes of this paper the research is limited to the area of mathematics in a first grade class. The writer proposes an action-research study to determine if an open structure program in the first grade will provide for the acquisition of skills equal to the skills acquired by first graders in a traditional program.

Statement of the Problem

The problem, as seen by this writer, is: Will an open structure math-center program in a first grade, in fact, be a more effective means for the acquisition of math skills than a mathematics program in a traditionally oriented first grade?

Importance of the Study

The results of this study will be the determining factor as to whether the math-center as herein described will be continued, revised, or rejected for further use in the writer's classroom and whether it will be considered for use in other classrooms in the Roosevelt Elementary School.

The results will be useful in aiding the administration when considering mathematics programs in other elementary schools in the district.


**Definition of Terms**

The following terms apply as used for the purpose of this study:

**Math center** - a design for math instruction in which the students are in direct contact, whenever possible, with actual objects, events and circumstances as necessary to meet their individual needs. The skill materials are sequenced and presented to the child at his individual level of experience and understanding.

**Traditional program** - a math program using the Addison-Wesley Elementary School Mathematics Book I as its basic text.

**Math skills** - computational and reasoning skills as defined by Project.

**Learning disabilities** - children with normal or potentially normal or above average intelligence who have learning disabilities arising from perceptual, conceptual or subtle coordinative problems, sometimes accompanied by behavior difficulties.
CHAPTER II
REVIEW OF RELATED LITERATURE

As this writer researched the literature for the present study the name of Jean Piaget appeared repeatedly as the prime referent.

Jerome Bruner (1967) classifies Piaget as "unquestionably the most impressive figure in the field of cognitive development."

Baldwin (1968) states:

Piaget's empirical research has contributed enormously to developmental psychology. In area after area, he has broken new ground and performed ingenious experiments; psychologists have been feeding upon his ingenuity since the 1950's and will probably continue to depend on his innovations for years to come. (1968, p. 298)

Hans Furth (1969) says:

Piaget was able, like Darwin or Freud, to systematize his empirical observations of children by discovering structures where others saw nothing but unconsequential childish activities. Einstein summarizes Piaget's developmental approach as "the idea of a genius, such simplicity." (1969, pp. 6-7)

What had this man done to cause the entire world to evidence such respect? Upon what research did he base his claims?

To aid the reader toward a greater appreciation of Piaget's contributions to psychology and education, the writer includes this biographical sketch which indicates the research thus far accomplished and the years
and years that have been devoted to scientific study and data collection by this most remarkable man.

Jean Piaget

The Man - His Works

Jean Piaget was born in the small Swiss university town of Neuchatel on August 9, 1896. His father was an historian who specialized in medieval history and his mother was a dynamic, intelligent, religious person. Jean was an outstanding student. While still in grade school, he published an article in a natural history magazine—a description of an albino sparrow he had observed in the park. The publication of this article led to a position with the local natural history museum where he helped the director classify the museum's zoological collection. While thus employed he contributed a series of articles to Swiss and foreign journals of zoology about molluscs. At age fifteen, he was offered a position as Curator of the molluse collection at the Geneva Natural History Museum. He declined the offer in order to complete his high school studies.

During his adolescence he spent a vacation with his godfather, Samuel Cornut, a Swiss scholar. Cornut sensed that Jean's interests were becoming too limited and so introduced him to the writings of the great philosophers. Deeply influenced by these men, Jean developed interest in epistemology, the area of philosophy dealing with the intelligence. Ginsburg
and Opper (1968) say that he now began to ponder the answers to such basic questions as: What is knowledge? How is it acquired? Can one gain an objective understanding of external reality, or is one’s knowledge of the world colored and distorted by internal factors? Although Piaget became fascinated by these issues, he felt that their solution could not come entirely from philosophy. A comparison of the attributes of philosophy and science convinced him that the philosophical approach was too speculative, and the scientific approach was too factual. What was needed was a linkage between the two.

Thus he began his search to find the bridge between the two disciplines: to find some way of integrating his biological and epistemological interests.

Pressures of his academic commitments delayed an active investigation into the answers to these questions. He completed his doctoral studies at his hometown university and received his Doctor of Philosophy degree in 1918, when he was 21 years of age, with a thesis on the distribution of different varieties of molluscs in the Valaisian Alps.

Now that he had completed his formal studies he could devote his energies to the study of psychology.

He accepted employment in Zurich at two psychological laboratories. It was here that he became acquainted with the works of Freud, and attended lectures of Carl Justav Jung and others, and in 1920 published an article
on the relations between psychoanalysis and child psychology. The more he pursued the subject the more he became convinced that speculation must be supplemented with scientific research.

In 1920 he accepted a position with Dr. Theophile Simon in the Binet Laboratory in Paris, where his assignment was to develop a French version of certain English reasoning tests. The task, at first was extremely boring to his creative mind, but he shortly became fascinated with the incorrect responses of the children. He realized that there were different kinds of common wrong answers among children of about the same age. Moreover, there were different kinds of common wrong answers at different ages. This was the first of three major events which were to have great impact upon his future pursuits.

As he considered the meaning of these mistakes he concluded that the thought of younger children was qualitatively different from older children and so rejected the quantitative definition of intelligence—a definition based upon the number of correct answers of a test. The real problem Piaget concluded, was to discover the different methods of thinking used by children of various ages (Ginsburg and Opper, 1968).

This conclusion demanded a new approach to the study of intelligence. Piaget decided upon an extremely flexible psychiatric method. He let the children's answers determine the questioning. He followed the children's line of thought without imposing direction upon it.
Piaget at this time also worked with abnormal children at the Salpetriere hospital in Paris. As he attempted to gain insight into the mind of the abnormal child, he discovered that the newly developed clinical method was inadequate since these children lacked the verbal skills necessary for adequate communication of their thoughts. At this point he added an important procedure: the child was required to manipulate objects as well as to answer verbally. Piaget, however, did not make the transfer of this procedure to normal children until years later.

The third major influence upon his investigations came about through his extensive reading in the area of logic. It occurred to him that abstract logic might be relevant in several ways to children's thinking. He discovered, for example, that a child younger than eleven was not able to carry out certain elementary logical operations. Thus, he set himself the goal of discovering how closely thought approximates logic.

In 1921 Piaget accepted the post of Director of Research at the Jean-Jacque Rousseau Institute in Geneva. This provided the opportunity to pursue his study of children's thought. During this time Piaget did a great deal of research and also taught various courses in psychology, sociology and scientific thought at Geneva and Neuchatel. His three children were born during these years: a daughter in 1925, and second daughter in 1927, and a son in 1931. Piaget and his wife, a former student, kept very detailed accounts of their observations of their children's physical
and intellectual development. These observations convinced Piaget that thought is derived from a child's action and not from his language. He then proceeded to modify his testing techniques and at this time recalling his work with the abnormal children at Salpetriere, he made the manipulation of concrete objects an essential part of the clinical method, with children at all ages. The emphasis was no longer on language alone, but on manipulation supplemented by language.

He had at last discovered a way in which he could combine his two great interests--epistemology and biology.

From 1929-1939 Piaget's professional life became even more active. He accepted an appointment as Professor of the History of Scientific Thought at Geneva University, he became co-director of the Jean-Jacques Rousseau Institute, he taught experimental psychology at Lausanne University, and he became involved in international affairs by accepting the chairmanship of the International Bureau of Education.

Piaget's experiences brought about changes in his thinking and in the next few years he accomplished much new research, printed many books and was joined by new associates in his work.

In the early forties Albert Einstein suggested to Piaget that it might be of interest to epistemology if he were to investigate the child's understanding of time, velocity, and movement. Piaget followed the suggestion and in 1946 published two volumes describing the results of the research.
Piaget searched for an understanding of the development of human intelligence for thirty years before he felt prepared to apply the results of his psychological research to the epistemological problems which had originally motivated his interest in psychology. In 1950 he published a three-volume series covering the various aspects of knowledge, including mathematics, physics, psychology, sociology, biology and logic. He then turned to the study of chance and probability.

In 1952 he was appointed Professor of Genetic Psychology at the University of Paris (Sorbonne), where he remained until 1962. At the same time he continued to teach at Geneva University and head the Jean-Jacques Rousseau Institute and pursue research into both perception and logical thought, publishing several volumes of findings. Following his investigations into early and middle childhood thought Piaget turned his energies to an investigation of adolescent and adult thought.

Piaget has devoted 40 years at the University of Geneva to the study of human development and to the study of the origin and growth of human knowing. Though more than 75 years old today Piaget still pursues his professional work as actively as in the past. He continues to produce new theories and new research, and is currently writing another book, bringing the total of books published to over thirty.

Bruner (1969) says that

... despite the magnitude of his work, Piaget still remains annoyed by pomp and shuns the spotlight except
when it concerns the developmental psychology of children. It seems that he always has a twinkle in his eye and most always wears a navy blue beret, smokes a meerschaum pipe, and rides a bicycle. Each summer, as soon as classes are over, he gathers up the research findings of his assistants, departs to solitary residence in the Alps, and walks, meditates, and writes and writes. But, back at school, he continues to teach his young experimenters to ask questions without suggesting answers and to test, by counter-suggestion, the strength of the child's conviction.

Though many of his studies have been repeated under more rigorous conditions (Piaget does not use computers) by other investigators, the results have been remarkably consistent with Piaget's. Now a new intelligence scale is being attempted on the basis of Piaget's tests.

It seems that all lives, those of children and their parents, will be affected by Piaget's work. As Bruner (1969) states: "Piaget has made us realize that the infant, like the adult, is constantly and effectively involved in an effort to bring order and logic and meaning into experience." "In an age of moon shots and automation," Elkind (1971) concludes, "the remarkable discoveries of Jean Piaget are evidence that in the realm of scientific achievement, technological sophistication is still no substitute for creative genius" (Elkind, 1971, p. 59).

**General Findings**

For Piaget the crucial question in the study of the growing child is how he adjusts himself to the world in which he lives.
David Elkind (1971) finds that

Piaget's genius for empathy with children, together with true intellectual genius (have) made him the outstanding child psychologist in the world today and one destined to stand beside Freud with respect to his contributions to psychology, education, and related disciplines. (p. 25)

Though it may be said of Piaget that "he is by vocation a sociologist, by avocation an epistemologist, and by method a logician," Jennings also states that Piaget

... tells his listeners and readers that he is not an educator (but) ... a psychologist with an interdisciplinary bent ... an investigator using the tools of the related fields of biology, psychology, and logic to explore the genesis of intelligence in the human young. All his long life he has drawn upon these fields to conduct research and to build his theories of the development of intelligence in children ...

Ironically, those who know Piaget best realize that only within the past decade have his writings come to be appreciated in America. (Much of his writing has not been translated into English.) The process of assimilating Piaget's ideas is a slow one, since there is so much to assimilate and because many of his ideas are contrary to prevailing modes of thought.

Elkind admits (1971) that "American psychology and education were simply not ready for Piaget until the fifties. Now the ideas that Piaget has been advocating for more than thirty years are regarded as exceedingly innovative and even as avant garde. The chief outcome of his theory in intellectual development is a plea that children be allowed to do their own learning."
Piaget would like educational systems to realize the limits of children's understanding at certain ages and plan curriculum compatible with development. For example, in the past the age of 6 or 7 was considered as the age of reason. It was assumed that the child's reasoning abilities were the same as the adolescent's or adult's. However, Piaget has shown that the elementary school child's reasoning ability is limited in a very important respect—he can reason about things but not about verbal propositions. Elkind (1968) believes that "attention to the research on children's thinking would help to avoid difficulties in the processes of the New Math program."

One of Piaget's most important contributions to psychology and education is his demonstration of the creative nature of children's thinking and learning. He argues that the mind is best thought of, not as a mechanical contrivance, but, rather as a creative artist. The true artist never simply copies reality nor does he merely execute some inner vision. Rather the artist brings his experience of reality and his inner vision together by means of a creative process which results in a product that is not reducible to its components. A good painting is a new reality which at one and the same time captures the artist's inner vision and his real experience (Elkind, 1971).

The products of the mind, so Piaget has shown, are created in much the same way as the artist creates the painting. Perhaps the simplest demonstration of this fact comes not from Piaget's own research but from the responses of different individuals to the inkblot test devised by Herman
Rorschach. When presented with these inkblots, the examinees see different things. In the same card, one person will see a butterfly, another will see two men supporting a woman, while still another person will see it as a badge with an eagle on it. What people see depends both upon the character of the blots and upon their personal experiences. Thus, an individual's response to an inkblot is a creation no less than the artist's painting (Elkind, 1971).

What Piaget has demonstrated is that much of our knowledge about the world is of the same nature as the responses to the inkblot, a product of our own predelictions and of our experiences. A child's ideas about number, space, time, and causality are never direct copies of what he has been taught or experienced nor are they ever simple projections of some fixed and innate ideas about these matters.

From Piaget's research, the following example shows how the child creates his world in the very process of learning about it. The child is presented with two identical glass beakers filled equally high with orange pop. The child is asked if there is the same amount of pop to drink in the two glasses. After the child has agreed that this is true, the liquid from one of the glasses is poured into a much taller and thinner glass in which it now reaches a much higher level than it did in the original beaker. The child is now asked to compare the amount of drink in the tall, narrow beaker with the amount of drink in the low, wide beaker and to way whether
one of the beakers has more to drink than the other or whether the two beakers contain the same amount.

When young children are confronted with this demonstration, their performance is quite predictable. They say that the tall, narrow container contains more liquid than the low, wide container. They persist in this judgment even when they are reminded that when the pop was in the other beaker it had the same amount of liquid as the low, wide beaker with which it is now being compared. Young children continue to argue, however, that there is more to drink in the tall, thin container because the level of drink in it is higher than the level in the other container. For the young child, that which he perceives has the most powerful influence upon his thinking.

If the demonstration is presented to an older child (usually ages 6-7), quite a different result is obtained. The older child says immediately that the amount of liquid in the tall, narrow beaker is still the same as the amount in the low, wide one because "nothing was taken away" or because "what was gained in height, it lost in width," or because "if you pour it back, it will be the same." These children recognized that a change in the appearance of a quantity of liquid did not amount to a change in its quantity. Piaget terms this understanding, that a quantity remains unchanged regardless of the transformation in its appearance, conservation.

Although Piaget's "conservation" experiments are well known, one feature of these experiments is often overlooked. Once a child attains
conservation, he assumes that the equality exists independently of himself and in the materials. In fact, however, the child arrived at conservation by reasoning. This is true because a simple comparison of two differently sized containers partially filled with liquid in and of itself gives no clues to the equality or inequality of the two amounts. The child, therefore, must reason from his previous experience of having seen the two amounts in identical containers at a prior point in time. It is on the basis of that prior experience that he reasons that the two quantities are now the same. In effect, the child arrives at conservation through reason but assumes that he arrived at it through observation.

It is "externalism" (the unconscious projection of our own mental constructions onto the external world) which prevents us, as adults, from recognizing that children are creating and integrating while they are learning. Inasmuch as we have already created and externalized our reality, it appears to us that the child's task is merely to copy that reality. We erroneously assume that we learned about the world by copying a pre-existing reality and just assume that all children do likewise. Piaget's greatness then lies not only in having shown us that children are creating while learning, but also, why we, as adults, have so much difficulty in perceiving this fact.
Piaget's Stages of Development

A second major contribution of Piaget to child psychology and education is his demonstration that learning is developmental in nature. The learning process is not static but rather evolves in a series of stages that are related to age. For Piaget, both the way in which children learn and what they learn is very much determined by their level of mental development.

Piaget has this to say about stage-age relationships:

The age of seven is a relative one in a double sense. In our research we say that a problem is solved by children of a certain age when three-quarters of the children of this age respond correctly. As a result, to say that a question is solved at seven years old means that already one-half of the six-year-olds can solve it, and a third of the five-year-olds, etc. So, it's essentially relative to a statistical convention. Secondly, it's relative to the society in which one is working. We did our work in Geneva and the ages that I quote are the ages we found there. I know that in certain societies, for instance in Martinique, where our experiments have been done by Monique Laurendeau and Father Pinard, we have found a systematic delay of three or four years. Consequently, the age at which those problems are solved is also relative to the society in question. What is important about these stages is the order of succession. The mean chronological age is variable. (Ripple and Rockcastle, 1964)

During the first stage (usually birth to two years) the infant is concerned with the creation of objects. The young infant does not really have any sense of objects as distinct from himself or any sense of himself as distinct from objects. When his mother leaves the room she is not only
out of sight she is out of his mind. By the end of the first year the infant begins to behave as if objects continue to exist even when they are no longer present to his senses. If asked, "Where's Mommy?" he will turn towards the door through which she just left the room. The creation of permanent objects (including himself as an object) is attributable to his increasing ability to coordinate his sensory-motor activities. An interesting example is a situation where an object is on something like a rug and the child can't actually reach it. At the beginning of the sensory-motor period, he is unable to reach it but by the end of that stage he pulls the rug with the object towards him. There are a number of relations that must be differentiated: first, the relation that the object is on the rug, and the relation between the object and the thing on which the child pulls something. And these two relations must be coordinated into one—the behavior (which is pulling the whole thing) and the object.

It is apparent, then, that in the first two years of life children live in a concrete world and in a series of situations. The interaction that is going on between a child and his physical and social world permits him to separate himself from his environment as well as to realize that the environment has certain properties of space, location, permanence, and causality. He is increasingly able to operate symbolically by classes or groups. He can tell that a dog is a member of the dog family but he cannot yet deal with the category "animal."
At the second stage (usually three-five years) the major task is to create symbols. Now that he has acquired a world of permanent objects, the child acquires the ability to represent these objects by images and words which greatly extends his ability to use these objects. Language plays an increasingly important role as the child acquires concepts through a complex set of processes. To attain concepts, he has to become increasingly aware of objects in his environment. He has to learn that they not only exist but that they have many characteristics and attributes. In addition, he must see that diverse items can be organized into classes or categories (animal, elephant, mammal, man, vertebrate).

Language, the major representational system to appear during this period, is also very creative. Recent work stimulated by the writings of Noam Chomsky has shown that young children very early attain grammars which are different from the grammars attained by older children and adults (Elkind, 1971).

One early grammar is the so-called "Pivot Grammar." With this grammar the child builds two word sentences of the kind, "Bobbi up," "Bobbi down," "Bryan go," "Bryan eat," and so forth, where one word serves as the pivot for many different constructions. In language, as in the domains of play (representational--children dressing up as adults) and in dreams (first reported in children after the age of two), children of
pre-school age are busily creating symbols thanks to the new representational abilities that emerge around the end of the second year of life.

Piaget breaks the pre-operational stage into two periods. The first occurs between the ages of two and four, the time when the child learns to name things, to ask questions, issue commands and to assert propositions. At this stage the child makes a giant intellectual step in his ability to differentiate between signifiers—symboles that stand for something—and significance—the objects. This representational intelligence sets the stage for the upper limits of cognition and the manipulation of reality. Piaget calls this the pre-concrete period, because children primarily grasp first-level concepts. They can grasp the fact that peaches and pears are food but cannot distinguish between different pears. Or they can recognize that certain very different things belong together—LaMar's hat, LaMar's chair, and LaMar's shoes.

Between four and seven years of age, the intuitive period, symbolic functioning increases. The child grasps images and signs as signifiers and begins to evoke acts and deeds in thought rather than actually carrying them out in reality. This ability to anticipate, to conjecture, to speculate, leads to the ability to hypothesize, to deal with variants and covariants, to test logically. In the life of a learner, this is an advance of the utmost importance.
Another cognitive advance that occurs at this stage is the ability to use numbers, not only to order things in terms of quantity but also to see that relationships can exist on a numerical basis. The latter part of the pre-operational stage finds children making judgments largely on the basis of partial and immediate perceptions or on the basis of objective similarity. They judge by the way things look and usually in terms of just one of a number of relevant dimensions. Even so, three fundamental operations occur. They can think in terms of classes: when presented with circles and squares, they can classify them on the basis of roundness. They can think in terms of relationships: Mr. Eldredge is the father of Jamie, Mr. Eldredge is bigger than Jamie, and Jamie is the third of four boys.

In the concrete operations stage (usually ages six to eleven) the thought of children is more like that of the adult, in that they can think more in logical terms. Operations is used by Piaget to refer to mental acts or imminent acts taking place in the mind. These mental acts represent a process of interaction and development whereby new syntheses are formed by discovery. Attributes are noted, objects are classified, and categories are determined. The syntheses are real in the sense that they not only have a location in time and space but also take place in the mind.

Three significant operations described by Piaget are reversibility, as in arithmetic \((2 + 3 = 5, \text{ or } 5 - 3 = 2)\); classification, or the organization of objects into classes (desk, chair, table = furniture); and seriation, or
arranging ideas along a spectrum of increasing values (2, 4, 6). In addition, the child understands the concept of conservation, that certain properties of objects, such as quantity, remain invariant even in the face of certain changes. For example, two circles each with a diameter of six inches remain the same even though one is cut into quarters and the other is cut into thirds. Cutting the circle does not change the area of the circle.

Beginning at the age of five or six, with the development of the ability to reason in a systematic, logical way, the child is now able to follow rules. Previous to this stage he could not play or live with rules. He made and broke rules pretty much as he saw fit (usually in a way that would make the adult lose the game) and therefore could not participate in games requiring rules, such as checkers, chess, etc. Nor could they live by rules imposed by society as evidenced by the need of parents to repeat the same prohibitions over and over again.

The school-age child's newly emerged capacity to create rules is manifest in the personal, social, and school domains. On the personal level children have internalized many rules which they will obey even in the absence of an adult. In the social domain, these children can now engage in all sorts of games with rules, from card games to football. In the academic domain, they are dealing with creating or recreating rules whether they are involved in math, science, literature, art or music.

The concern for rules dominates the elementary school years. Many academic difficulties encountered by young people are often the result of a
deficiency of this rule-making ability or of the formation of erroneous or interfering rules. In mathematics, many children have difficulty because they learn only rule and assume that it applies to all instances and so do not see that there are many rules that have to be applied in different circumstances. Reading, too, from the very outset, involves rule-learning. Formal instruction in reading could well be delayed until the child has demonstrated that he has the capacity to create and to follow rules.

The fourth and last Piagetian stage (usually ages twelve to fifteen) can be said to be primarily concerned with the creation of thought. Elementary children think, but they do not think about thinking. Now the child begins to deal with the possible without reference to the actual. This new capacity to conceptualize thought is attributable to the emergence at about the age of twelve of what Piaget calls "formal operations." These formal operations enable young people to create a second, higher order symbol-system, a system of symbols for symbols or language for language. It is this second order symbol-system which allows adolescents to deal with algebra and symbolic logic on the one hand and to think about thinking on the other. As Hunt (1961) puts it, "instead of observation directing thought . . . the adolescent's thought directs his observing."

**Learning**

According to Piaget, then, learning is not a circumscribed process but it is rather an essential part of living and growing. A child does not
learn only when he is sitting quietly at his desk or when he is listening to his teacher. The child is learning all the time and the question is not whether he is learning but rather what he is learning.

The fact that a child is learning all the time is really not a very new idea, but it is one which is often overlooked.

In his classic, *Experience and Education*, John Dewey said it is not enough to insist upon the necessity of experience to education but that everything depends on the quality of the experience. He states "the more definitely and sincerely it is held that education is a development within, by, and for experience, the more important it is that there shall be clear conceptions of what experience is." Experiences must be more than immediately enjoyable; they must promote fruitful and creative subsequent behavior. Educationally, this must be done in such a way that each pupil's power of judgment and capacity to act intelligently in new situations is in harmony with the principle of growth. This is the theory of continuity of experience, which means that "every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after (Dewey, 1938). This is principally what differentiates civilization from savagery, and to a considerable degree, the curiosity and creativity of the normally developing child from the overindulged child.

At the "Jean Piaget Conference of Cognitive Studies and Curriculum Development" held in 1964 at Cornell University and the University of
California at Berkeley, Piaget discussed four basic factors which contribute to intellectual development. They are 1) physiological development, 2) direct experience with the physical world, 3) social transmission (communication, teaching, etc.) and 4) equilibration or autoregulation.

It is the last of these four factors that Piaget has studied in depth. It has been given little attention though it is of fundamental importance. As a child's physiological system matures, he is bombarded with many experiences and he is presented with much information. But intellectual development is not this passive; it involves acts or operations by the learner. These acts, or mental operations, on objects in the physical world involve revising partial understandings, broadening concepts, and relating one idea to another.

In essence, the idea of activity—a child's need to reach by his own efforts an understanding of the world in which he lives and the experiences in which he participates—represents Piaget's first critical variable in the teaching-learning situation. A child may accommodate his thoughts to those of others, but, only when he tries out the ideas of others to see how they function and retraces the ideas, can he then assimilate ideas and make them his own.

Copeland (1970) uses the following example to clarify the process of equilibration:

The child is confronted with a problem involving two balls of clay the same size. One ball is made into two
smaller balls and the child is asked which will make the water in a glass of water rise higher—the large ball or the two smaller balls. The child answers that the two smaller balls will. Why? Because there is more. The experiment is conducted and the water is found to rise the same amount in both cases. Some children are unable to reconcile the apparent contradiction. Others are able to assimilate this new information and generalize a correct answer for similar experiments. Piaget would say that the second group has achieved a mental equilibration. Their mental processes have accommodated this new information, generalized it, and it is now a part of their mental structures.

For this equilibration to occur, the child must act or "operate" himself upon the objects. It is not sufficient to explain why if ideas are to become a part of his own mental structures. (Copeland, 1971, pp. 12-13)

Lavatelli (1970) stresses that self-activity is crucial to equilibration. She says that the child must be mentally active if equilibration is to be achieved. He must transform the data. The elements to be incorporated may be present in an experience, or the child may be told of the error of his thinking, but unless the mind is actively engaged in wrestling with data, no accommodation, or false accommodation occurs. Children, like adults, are not convinced they are wrong merely because someone tells them that they are. They have to act upon the data and transform it.

Piaget, in summing up a talk on development and learning, said all his remarks represented the child and the learning subject as active: "Learning is possible only when there is active assimilation." He had said earlier that, if the development of knowledge is to be understood, we must grasp the idea that to him is central: the idea of an operation.
Knowledge is not a copy of reality. To know an object, to know an event, is not simply to look at it and make a mental copy, or image, of it. To know an object is to act upon it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed. An operation is thus the essence of knowledge; it is an interiorized action which modifies the object of knowledge. (Ripple and Rockastle, 1964)

Psychological research, then, has shown that logic is not innate and the child cannot stay passive, but must act in order to develop.

**Learning Centers**

There are several methods of teaching available for use in the classroom. These can be classified as verbal, intuitive, and the active methods. Active teaching becomes ideal when a balance is obtained between individualization and socialization. According to Piaget, the central point in the active method lies in spontaneous construction. The key is not the method of the teacher, but in the freedom left for the child to spontaneously build his operations. The role of the teacher primarily consists in providing the materials which the child needs and being careful to suggest only that which is indispensable. The child who has studied a problem according to this method, will always be able to rediscover it; he will be less likely to forget the solution which he found by personal reasoning.

Psychologists, educators, and learning theorists have devoted years to the study of the processes by which learning takes place. Their findings
have caused many to question traditional teaching methods and to search for techniques more in accord with the dynamics of learning.

Jerome Bruner (1964) is one respected learning theorist whose ideas support the laboratory approach.

The writings of Zoltan P. Dienes (1964) stress the student’s need to explore several physical manifestations of a concept and to synthesize these experiences in order to form the concept.

Teaching must address itself primarily to the senses: start with the concrete, the visible, the tangible, and then progress to abstract relationships. Piaget concluded that the manipulation of objects must precede any mental development.

Froebel demanded that children should be treated as children and that childlike characteristics such as curiosity should be utilized in education (Biggs and MacLean, 1969).

Pestalozzi tried to move away from a method of teaching which was all words, insisting that wherever possible, children should also learn by touch and sensation (Biggs and MacLean, 1969).

Biggs and MacLean also say that if a child only hears, but does not see, he does not learn as well as if he hears and sees at the same time. If he can touch as well as hear and see, he will learn far more soundly. The image of the teacher as the fountain of all knowledge occupying the front and center of the classroom, dominating and directing all activity must disappear. They continue their discussion with this commentary:
There will always be a place for exposition by the teacher, for an account of something interesting and important, whether it be to an individual, a small group, or the whole class. The only difference is that more teachers will be doing what the best teachers have always done. They do not give a lesson but provide a focus for discussion. The children are encouraged to comment and to ask questions as the lesson proceeds. It is at this stage that the teacher's skill and his recognition of individual needs is important. He must not be too quick to cut off seeming irrelevancies or to label a response as incorrect or silly.

Dr. Albert Schweitzer suggested that "only those who have respect for the opinions of others can be of real use to them." A child never gives a wrong answer. Every problem response that he makes is right for him on the basis of his present knowledge and background of experience. A relationship of mutual trust and respect, in which coercion and punishment have no place and where marks and rewards are unnecessary, is the kind of relationship which distinguishes a "modern" classroom from a "traditional" one.

The Ontario Department of Education (1968) suggests that the modern professional teacher is a person who guides the learning process. He places the child in the center of learning activity and encourages him and assists him in learning how to inquire, organize, and discuss, and to discover answers to problems that interest him.

Specifications for the learning center model of education were first expressed by Rousseau in 1762 when he wrote in *Emile*:

Teach your scholar to observe the phenomena of nature; you will soon rouse his curiosity, but if you would have it grow, do not be in too great a hurry to satisfy this curiosity. Put the problems before him and let him solve them himself. Let him know nothing because you have told him, but because he has learned it
himself. Let him not be taught science, let him discover it. If ever you substitute authority for reason, he will be a mere plaything of other people's thoughts. 

... Undoubtedly, the notions of things thus acquired for oneself are clearer and much more convincing than those acquired from the teachings of others; and not only is our reason not accustomed to a slavish submission to authority, but we develop greater ingenuity in discovering relations, connecting ideas and inventing apparatus, than when we merely accept what is given us and allow our minds to be enfeebled in indifference. (Rousseau, 1762, p. 131)

Jerome Bruner (1967) encapsulated the problem of inquiry when he wrote, "Let us not judge our students simply on what they know. That is the philosophy of the quiz program. Rather, let them be judged on what they can generate from what they know—how well they can leap the barrier from learning to thinking."

The learning center approach is based on the premise that people need to solve problems and they can learn to do so. Problems require knowledge of problem-solving techniques, and yet techniques vary from problem to problem. It is difficult to train people to solve problems. Any complex task (for example, climbing a mountain or playing a piano) demands training, and problem solving is no exception. Training is provided by having the student solve problems (or play the piano or climb mountains) under the direction of a teacher who is an expert in solving mathematical problems (or playing the piano or climbing mountains).

In the preface to his book on mathematical discovery Polya (1962) has written the following:
Problem solving is a practical art, like swimming, or skiing, or playing the piano; you can learn it only by imitation and practice. . . . If you wish to learn swimming you have to go into the water, and if you wish to become a problem solver you have to solve problems.

A learning center approach, and particularly a mathematics learning center, with its emphasis on individual student manipulation of objects, brings a sense of realism into the classroom. Mathematics takes on a relevance seldom present when the normal textbook method of teaching is used.

Through observation and handling physical objects, the child can gain experience from which he can construct mathematical concepts.

In a center the child can gain background in all aspects of problem solving. The surroundings of physical objects aid him in sizing up the problem and in selecting feasible methods of solution. We find that if arithmetic is imposed on a child before he has developed the necessary pre-number concepts, he merely memorizes, so storing up trouble for the future. He has to learn symbols before he has anything to symbolize. Many first graders fill out workbook exercises without really knowing what they are doing. This leads to a dislike of math which usually shows up between the ages of six and eight.

The significance of the research as contained in the literature is that children cannot learn number, length, time, etc., in isolation from natural experiences. The development of children's abilities to think and
learn in logical patterns comes through experiences with physical objects. Children gain understanding not from the object, nor from what we tell him about the objects, but from their own action upon the objects. First hand experience is the key. Children are capable of a high order of logical reasoning if given materials which they can understand.

After contemplating the vast intellectual development which occurs in the years preceding school entrance, it seems that a mockery is made of "learning" by placing the child in a "sterile" classroom and pretending that the best way for him now to learn is by filling in page after page in a book someone wrote who never saw him and knows nothing of the background of experience he brings to school with him.
CHAPTER III

PROCEDURE

Design of the Study

Recent research strongly indicates that first-grade-age children are better able to learn when they can deal directly with concrete objects. Proponents of this research suggest the use of a math-lab or -center approach to learning in which the math experiences emanate from the child's natural environment and his experiences are based upon his own interests and needs.

Opponents contend that math is a sequential process and the child must learn one process after another in proper sequence. Any other approach tends to confuse and to impede learning, thus making it impossible for the child to learn the necessary mathematical functions.

Therefore, this study was designed to determine if Roosevelt Elementary School first grade students in a math-center program could acquire greater mathematical skills than first grade students working in a traditional workbook program.

Therefore, a math-center was designed to meet the individual needs of the students within a self-contained first grade classroom at the Roosevelt Elementary School. A control group was established in another self-contained first grade classroom in the same school. The traditional
math program in this room was Addison-Wesley Elementary School Mathematics, 2nd Edition, Book I.

**Hypotheses**

The following hypotheses were tested:

**Hypothesis I**

The children in the treatment (Piaget) group will make greater gains in achievement than the children in the control group.

In testing this hypothesis the following questions were asked:

1) Will the total gains for the treatment group be greater than the total gains for the control group?

2) Will the gains made by the boys of the treatment group be greater than the gains made by the boys of the control group?

3) Will the gains made by the girls of the treatment group be greater than the gains of the girls in the control group?

**Hypothesis II**

The high-ability child will make greater gains in achievement in the treatment group than the high-ability child in the control group.

In testing this hypothesis the following questions were considered:

1) Will the high-ability students' gain in the treatment group be greater than the high-ability students' gain in the control group?
2) Will the students with average ability in the treatment group gain be greater than the average-ability students' gain in the control group?

3) Will the low-ability students' gain in the treatment group be greater than the low-ability students' gain in the control group?

4) Which students--high, average, or low ability--will make the least gain in the treatment group? in the control group?

Hypothesis III

The child with a visual-motor integration disability will make greater gains in the treatment group than the child with the same disability in the control group.

In testing this hypothesis, the following questions were asked:

1) Will the disabled child in the treatment group make greater gains than the disabled child in the control group?

2) What will the gains of the VMI disabled child be as compared with the gains of the non-VMI disabled child within the treatment group? within the control group? across groups?

3) Will there be greater gains for the VMI disabled boys as compared with the gains of the VMI disabled girls in the treatment group? in the control group? across groups?
Hypothesis IV

The child's placement of the Piagetian-based assessment of intellectual development will correspond positively with his scores on the Metropolitan Achievement post-test.

Testing Procedures

All students were administered the math subtest of the Metropolitan Achievement Test--Primary I and the Test of Basic Experiences--Mathematics--Level I as pre- and post-tests of math skills and experiences. These tests were given by October 1971 (pre-test) and by May 1, 1972 (post-test).

All students were given the Developmental Test of Visual-Motor Integration on January 26, 1972, to determine those students who were disabled in the area of visual perception and motor coordination integration.

In May 1972 all students were given the Primary Mental Abilities for grades K-1 to identify those students having high-, average-, or low-ability.

All students in the treatment group were given an informal assessment of intellectual development (based upon the research of Piaget) shortly after entering school in the fall. Their re-evaluation was continuous throughout the year.

The testing was done by personnel other than the classroom teachers (with the exception of the Piaget-based assessment) and the test results were
not made available to either teacher until after the post-testing was completed.

The teacher variable factor could not be controlled. However, both teachers entered a new program of mathematics instruction which minimized familiarity with a program as a variable.

Students entering first grade were ranked using the scores obtained in the Metropolitan Readiness Test which was administered in the spring of 1971. The five students with the lowest scores on the Metropolitan Readiness Test were placed in the treatment group. The remaining students were assigned by ascending scores, alternating in the three first grade sections.

**Experimental Group**

Based upon the review of literature, a math center was established in the Roosevelt Elementary School in a first grade classroom for the experimental group.

All the children in the experimental group were individually screened to determine their understanding of pre-number (as outlined by Piaget—classification, seriation, class inclusion, and conservation of numerosity) and number concepts by an informal screening inventory designed by the writer.*

*The program used is available from the author.
A solution designed by this writer was to provide relevant material in sufficient quantity and variety in a math center from which the teacher could draw to teach the children the skills they needed to learn to continue the intellectual development already begun in the pre-school years.

The general objectives of the math-center were:

To stimulate the students' thinking about the world around them

To lead them to independence in problem solving skills

To provide materials, apparatus, and strategies for problem solving

To teach the use of mathematical devices

To teach the computational skills of arithmetic

To suggest possible solutions and give direction to thinking, but not to supply answers to questions

To work with children in small groups and/or individually as much as possible, grouping flexibly according to needs, interests, and development

To provide time for child-directed investigations.

The specific sequenced objectives for the treatment (Piaget) group were:

The students will show competency in

Classification

1) by identifying properties of objects (size, shape, color, etc.) and matching objects by more than one property
2) by keeping in mind two or more properties of objects at the same time while searching for any object to complete a set

3) by combining objects to make up subclasses and combining subclasses to make supra-subclasses, and recognizing the existence of complementary classes

4) by changing from one criterion for grouping to another

5) by taking a whole class apart to find subclasses, and making comparisons of "all" and "some"

6) by discovering intension and extension of a class

7) by visualizing an object as having simultaneous membership in two classes

8) by putting together elements from several groups so that none is repeated

9) by making all possible combinations of elements

Seriation

1) by arranging 10 or more items in a series according to one variable only

2) by arranging items in a series according to more than one variable

3) by inserting an object into an already completed series

4) by solving a double seriation matrix

5) by achievement of transitivity

Conservation

1) by showing the physical correspondence of objects on a one-to-one basis

2) by recognizing a one-to-one correspondence when physical correspondence is destroyed
3) by being able to recognize conservation of quantity

4) by being able to recognize that whole is conserved when the additive composition of its parts is varied

5) by recognizing that area is conserved even though its appearance may be changed

6) by being able to picture objects following a transformation of perspective

Understanding of mathematical terminology

1) by demonstrating the meanings of the following terms:

- more
- less
- the same
- as many as
- before
- after
- tall
- short
- wide
- narrow
- high
- across from
- opposite
- the same side
- the other side
- left
- right
- heavy
- light
- old
- young

the same way
some other way
not as much
taller than
higher than
shorter than
the same length as
on top of
under
along side of
near
close to
up against
by
in back of
in front of
first
middle
last
next
low

Skills

1) by demonstrating at the 80% level of proficiency

- sets
- empty sets
- write 0-99

greater than
less than
equal to
addition (sum not to exceed 20)
subtraction (factors not to exceed 20)
horizontal notation
vertical notation
operational sign insertion
circle
square
triangle
rectangle
line
line segment
inch
foot
yard
cup
pint
quart
gallon
tell time on the hour
in weighing to the nearest half pound
identifying pieces of money
  penny
  nickel
  dime
  quarter
  dollar
value of money
reading a thermometer (hot or cold)
fractions
  $\frac{1}{2}$
  $\frac{1}{4}$
  $\frac{1}{3}$

To meet the outlined objectives the class organization was very flexible. Each day all the children spent time in the math-center. Their experiences depended upon their progress towards competency in the objectives. The children were encouraged to help with their charts which were kept in a Student Record Book, so they might see the tangible evidence of their progress. (See Appendix.)
The math-center provided opportunity for individual growth and development of understanding. The teacher's role was to encourage and assist in the growth and to open the way for acquisition of new skills.

Included in this math-center were many manipulative items: bottles and jars of all sizes and shapes of objects to fill them (rice, sand, beans, blocks); scales and balances for weighing and making comparisons; objects for classifying, matching, comparing and counting (the whole school served as resources); rulers, yardsticks, tape measures, string, clocks and stopwatches for measuring observations.

Each day (from after Christmas until the last day of school) the children came to the math-center on a scheduled basis. Since there were six other centers in the room, no more than four came at one time, and they could be grouped according to their needs and abilities in regard to the skills being taught that day or that week. They spent about twenty minutes working with the teacher in the center each day. Exercises varied from worksheets to games, or teamwork or challenge contests, as well as discussions between students or between students and teacher. Problem solving skills were developed at this time. Materials for solving problems were available and the children were encouraged to devise their own solutions, as many and as varied as they could. Solutions were often expressed in the form of graphs, charts, or pictorial representations. Symbolism was encouraged as soon as it was meaningful. The children were
encouraged to think out loud and expressed surprise when they discovered that different thought approaches would produce the same correct answer.

The children were free to think through their problems in their own way and notation was expected only of those who were developmentally (according to Piaget's Assessment of Logical Thinking—Lavatelli, 1970) prepared for it. They were involved in discovering the orders, patterns, and relations of things in their world which is the very essence of mathematics.

Mathematics was an integral part of the children's life. It was not something that was done for an hour after lunch. Rather, the math-center was always open and well-stocked with items of interest. Whenever a child expressed a desire to resolve a problem or question that was in his mind, such as "How much is three threes?" he was guided to an answer right then without having to wait for "math-time." If the teacher was unable to help, another child would help him. The children understood that they were not to give answers but to ask him some questions which would lead the student to his own solution.

The mathematical challenges centered around life experiences. Since the intellectual development ranged from those who were able to think abstractly about some things to those who were wrestling with the pre-number concepts, there needed to be a great range of challenges and expectations.
For instance, during science the size of dinosaurs, or whales or
elephants was being discussed; the children found tape measures so they
could mark those lengths off in the hallway. Masking tape was put down,
marked with twenty feet, thirty feet or whatever the measurement so it could
be used for future measuring or making comparisons of the varying sizes of
animals. The sizes of animals were graphed for making comparisons.
Which is larger? How much larger? or heavier? or taller?

Counting and tallying experiences often came from social studies.
For example, as different kinds of dwellings were discussed the children
became interested in the number of doors and windows different people had
in their homes. With note pads and pencil they tallied 93 panes of glass in
the hallway of the first floor of the school. They graphed their findings and
made a poster to put in the hall offering a challenge to the other students in
the school to check their findings.

The lack of pedestrian crossings and traffic signals was a matter of
great importance to the community and the children took turns tallying the
number of cars which passed in front of the school.

Their heights and weights were graphed in the fall. Gains in the
spring were graphed and comparisons made—tallest, heaviest, gained
most, gained least. They also compared boys and girls, chairs and chil-
dren, those wearing red socks with those wearing blue and wrote their
findings in mathematical language. If there are fourteen boys here today
and nine girls, will twenty-one chairs be enough? Is the sum of the children
greater than the number of chairs? How much greater? Is the number of
boys wearing blue socks greater than the number of girls wearing blue socks?
How much greater? If there are fifteen boys in our class and nine girls, how
many more girls do we need to have an equal number of boys and girls?
Their findings were graphed or illustrated pictorially and displayed about
the room and in the hallway so that others could read and discuss them.

Conversation was encouraged and the children became skilled at ex-
changing ideas. Mathematics was not just something to be discussed during
a certain time each day but it became part of living.

Control Group

In the control group the Addison-Wesley Elementary School Mathe-
matics, 2nd Edition, Book I was the text. The entire class proceeded through
the textbook in the order in which it was published.

The objectives of the program as stated by the authors are as
follows:

to introduce and develop understanding of the areas listed:

copyright 1960 by Addison-Wesley

concepts of more and less
equivalent sets
relationships between sets
counting
coins and money problems
number line
symbols of inequality relations
the concept of addition to 13
equality and equations
sloping equations
vertical addition
the concept of subtraction to 18
the inverse relationship between addition and subtraction
the feeling for real-life situations by discussing story problems
place value for two-digit numbers
order, parentheses, and the grouping principle of addition
the nickel and the dime and problems with money
telling time
three addend addition
odd and even numbers
"skip-counting"
linear and liquid measure
fractions
to teach the following:

the order of numbers 0-99 (Eicholz, 1968)

It is interesting to note that the objectives of this program are mainly introduction and development of understanding. Only one concept (the order of numbers 0-99) is outlined as needing to be taught. Nothing is mentioned concerning mastery of any skills.

The class met for math following noon recess each day. The group remained together for the first seven months working on x-number of pages each day. Group instruction preceded each work period with individual needs being met as they worked in their books. Additional drill was given to all students in the form of dittoed worksheets prepared by the publisher. Towards spring the more advanced students were allowed to go ahead on their own coming for help as they needed it. The rest of the group remained together.
Following each unit the mastery tests prepared to accompany the books were administered to all students.

Manipulative objects and math games were used by those who finished the page before the rest of the class. Counters were used by some for computation.

All the children completed all the pages in the text before the close of the school year.
CHAPTER IV

FINDINGS

Statistical

The pre- and post-test scores, VMI scores, and PMA scores were processed at the computer center.

To obtain the data for Hypothesis I a two-way-analysis was run on sex and group.

To obtain the data for Hypothesis II, a two-way-analysis was run on group and PMA trichotomy.

To obtain the data for Hypothesis III, a three-way-analysis was made on sex and VMI trichotomy and group with PMA raw scores as the covariate.

All scores used were raw scores since there were no standard scores available for the TOBE. It is recognized that this does not make as tight an analysis as would otherwise be possible.

Points gained from pre-test to post-test are designated as gained-scores. Total gained-scores equate with the points gained on the TOBE and MAT combined.

High-ability students scored 110 upward on the PMA. Average-ability students scored between 90 and 109 and low-ability students scored below 90.
On the VMI those students designated as disabled in the area of visual-motor integration were those who scored four months below their chronological age. Average students were those who scored three months above or below their chronological age and the high students scored four or more months above their chronological age.

**Hypothesis I**

The children in the treatment (Piaget) group will make greater gains in achievement than the children in the control group as indicated by pre- and post-tests on MAT and TOBE.

The mean of the total gained-score in the treatment group was greater than the mean of the total gained-score in the control group.

<table>
<thead>
<tr>
<th></th>
<th>Total gained-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>36.34</td>
</tr>
<tr>
<td>C-group</td>
<td>32.56</td>
</tr>
</tbody>
</table>

The mean of the total gained-score by the boys in the treatment group was less than the mean of the total gained-score in the control group. The mean of the total gained-score by the girls in the treatment group was greater than the mean of the total gained-score by the girls in the control group.
Table 2. Mean of total gained-score by boys and by girls in treatment group and control group.

<table>
<thead>
<tr>
<th></th>
<th>Total gained-scores</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-group</td>
<td>30.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-group</td>
<td>43.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the TOBE, the treatment group boys' and girls' mean of gained-scores was almost equal while in the control group the mean of the boys' gained-scores was greater than the mean of the girls' gained-scores. The treatment group girls achieved substantially higher gained-scores than the girls of the control group.

Table 3. Mean of gained-score by boys and girls in treatment group and control group--TOBE.

<table>
<thead>
<tr>
<th></th>
<th>TOBE</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-group</td>
<td>5.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-group</td>
<td>-1.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the MAT, the boys' and girls' mean of gained-scores was greater than the mean of the gained-scores for the boys and girls in the treatment group. The girls' mean of gained scores was greater than the mean of the boys in the treatment and in the control group.
Table 4. Mean of gained-score by boys and girls in treatment group and control group--MAT

|       | MAT
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>T-group</td>
<td>25.03</td>
</tr>
<tr>
<td>C-group</td>
<td>32.63</td>
</tr>
</tbody>
</table>

Hypothesis II

The high-ability student will make greater gains in achievement in the treatment (Piaget) group than the high-ability student in the control group.

The mean of the total gained-score of the high-ability students in the treatment group were only slightly higher than the mean of the total gained-score of the high-ability students in the control group. The mean on the gained-score by the average-ability students was also greater for the treatment group than for the control group. While the low-ability students in the treatment group showed a substantially higher mean of gained-scores than the low-ability students in the control group. (See Table 5.)

When considering only the TOBE, the mean of the gained-score of the students in the treatment group was greater than the mean of the students in the control group at the .05 level of significance. The students with average-ability in the treatment group had a mean of gained-score
Table 5. Mean of total gained-score of high-ability, average-ability and low-ability students in treatment group and control group.

<table>
<thead>
<tr>
<th>PMA</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>.97</td>
<td>3.31</td>
<td>13.22</td>
</tr>
<tr>
<td>C-group</td>
<td>-1.52</td>
<td>-.14</td>
<td>4.22</td>
</tr>
</tbody>
</table>

greater than the average-ability student in the control group had a mean of
gained-score greater than the average-ability student in the control group.
The mean of the gained-scores of the low-ability students in the treatment
group was greater than the mean of the gained-scores of the low-ability
students in the control group at the .05 level of significance.

Table 6. Mean of total gained-score of high-ability, average-ability and low-ability students in treatment group and control group--TOBE.

<table>
<thead>
<tr>
<th>PMA</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>.97</td>
<td>3.31</td>
<td>13.22</td>
</tr>
<tr>
<td>C-group</td>
<td>-1.52</td>
<td>-.14</td>
<td>4.22</td>
</tr>
</tbody>
</table>

The data from the MAT shows that the mean of the gained-score of
the high- and average-ability students in the control group was greater than
the mean of the gained-score for the like group in the treatment group.
But, that the mean of the gained-score for the low-ability students was greater in the treatment group.

Table 7. Mean of gained-score of high-ability, average-ability and low-ability students in treatment group and control group—MAT.

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>28.49</td>
<td>31.74</td>
<td>31.24</td>
</tr>
<tr>
<td>C-group</td>
<td>30.24</td>
<td>34.02</td>
<td>30.74</td>
</tr>
</tbody>
</table>

There is a difference in the mean of the IQ scores obtained from the students in the two groups. The mean of the IQ of the treatment group was less at the .05 level of significance.

Table 8. The mean of the IQ of students in treatment group and control group.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PMA</td>
<td></td>
</tr>
<tr>
<td>T-group</td>
<td>99</td>
</tr>
<tr>
<td>C-group</td>
<td>104</td>
</tr>
</tbody>
</table>
Table 9. The mean of the IQ of the high-, average-, and low-ability students in treatment group and control group.

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>116</td>
<td>99.6</td>
<td>81.9</td>
</tr>
<tr>
<td>C-group</td>
<td>115.2</td>
<td>101.7</td>
<td>81.0</td>
</tr>
</tbody>
</table>

Hypothesis III

The child with a visual-motor integration disability will make greater gains in the treatment (Piaget) group than in the control group.

The disabled child in the treatment group had a greater mean of gained-scores than the disabled child in the control group. Within the treatment group and the control group the mean of the gained-scores for the disabled child was greater than for the non-disabled child. The children in the average range in the treatment group had a mean of gained-scores which was considerably lower than for any other classification in either group. The mean of the gained-scores for the VMI-disabled children was almost equal to the mean of the gained-scored of the students classed as high VMI ability students in the treatment group. Within the control group, the mean of gained-scores for all students was very similar. (See Table 10.)

In the treatment group the mean of the gained-scores of the VMI-disabled were greater than the mean of the gained-scores of the VMI-disabled
Table 10. Mean of gained-score of VMI-disabled students in treatment group and control group.

<table>
<thead>
<tr>
<th>VMI</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>38.78</td>
<td>27.19</td>
<td>37.83</td>
</tr>
<tr>
<td>C-group</td>
<td>33.53</td>
<td>34.13</td>
<td>35.26</td>
</tr>
</tbody>
</table>

student in the control group at the .05 level of significance, when the gained-scores of the TOBE are considered. (See Table 11.)

The VMI-disabled students in the control group had a mean of gained-scores greater than the VMI-disabled students in the treatment group on the MAT. (See Table 12.)

Table 11. Mean of gained-score of VMI-disabled students in treatment group and control group—TOBE.

<table>
<thead>
<tr>
<th>VMI</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>4.73</td>
<td>3.69</td>
<td>9.11</td>
</tr>
<tr>
<td>C-group</td>
<td>2.31</td>
<td>-1.43</td>
<td>1.63</td>
</tr>
</tbody>
</table>

Table 12. Mean of gained-score of VMI-disabled students in treatment group and control group—MAT.

<table>
<thead>
<tr>
<th>VMI</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-group</td>
<td>34.03</td>
<td>23.50</td>
<td>28.71</td>
</tr>
<tr>
<td>C-group</td>
<td>31.09</td>
<td>35.55</td>
<td>33.60</td>
</tr>
</tbody>
</table>
The boys with a VMI-disability had a mean of gained-scores greater than the girls with a VMI-disability when the scores of the two groups are combined and the total test battery of gained-scores is considered. (See Table 13.)

When considering the mean of the gained-scores of the boys from both groups together, it is substantially greater than the mean of the gained-scores for the girls of both groups. (See Table 14.)

On the MAT the mean of gained-scores for the girls was greater than the mean of gained-scores for the boys. (See Table 15.)

Table 13. Mean of gained-score by VMI-disabled boys and girls.

<table>
<thead>
<tr>
<th>VMI</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>32.98</td>
<td>26.78</td>
<td>38.47</td>
</tr>
<tr>
<td>Girls</td>
<td>39.33</td>
<td>34.54</td>
<td>34.62</td>
</tr>
</tbody>
</table>

Table 14. Mean of gained-score by VMI-disabled boys and girls--TOBE.

<table>
<thead>
<tr>
<th>VMI</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>3.1</td>
<td>.37</td>
<td>8.05</td>
</tr>
<tr>
<td>Girls</td>
<td>3.88</td>
<td>1.88</td>
<td>2.69</td>
</tr>
</tbody>
</table>
Table 15. Mean of gained-score by VMI-disabled boys and girls--MAT.

<table>
<thead>
<tr>
<th></th>
<th>VMI High</th>
<th>VMI Average</th>
<th>VMI Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>29.69</td>
<td>26.40</td>
<td>30.39</td>
</tr>
<tr>
<td>Girls</td>
<td>35.43</td>
<td>32.65</td>
<td>31.93</td>
</tr>
</tbody>
</table>

Program--Piaget

Hypothesis IV

The students who score the highest on the informal inventory of skills based on Piaget's levels of intellectual development will be those students who also score the highest on the formal tests of mathematical achievement.

Since the informal assessments of Piaget do not lend themselves to computer analysis, the analysis of this aspect of the math center program will be less formal. (See Appendix A.)

Those students who exhibited competency at the 90% level of proficiency were considered to have scored in the "high" range. They were performing at stage three of the pre-operational level of intellectual development. They did not waver in their knowledge and understanding of the concepts assessed.

Those who completed the assessment with a proficiency level of 50-80% were classed as being in the "average" range and in stage two of the pre-operational level of intellectual development. They seemed to be sure of some concepts but were wavering in their complete understanding.
They could not always substantiate their "feelings" with a logical explanation.

Those who completed the assessment with a proficiency level of less than 50% were classed as being in the "low" range and in stage one of the pre-operational level of intellectual development. They were not able to give reasons for their thinking and they persisted in their wrong answers.

There were seven students who scored 90% or better on the assessment of intellectual development and those seven scored in the high range (missed six or less out of 64) on the MAT. There were seven who scored from 80% to 50% on the developmental assessment and eight who scored in the average range (missed seven to 20) on the MAT. Four students scored below 50% on the assessment and three scored in the low range (missed more than 20) on the MAT.

Table 16. Student ratings in Piaget and MAT tests.

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Average</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piaget</td>
<td>7</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>MAT</td>
<td>7</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>
SUMMARY AND CONCLUSIONS

Summary

Recent research strongly indicates that first grade children are better able to learn when they can deal directly with concrete objects. Proponents of this research suggest the establishment of a math-lab or -center in which the math experiences emanate from the child’s natural environment and he investigates and discovers through the manipulation of concrete objects. Learning experiences are based upon his discoveries and interests.

Opponents contend that math is a sequential process and the child must learn one process after another in proper sequence--that proper sequence having been outlined by the writers of mathematics textbooks. They further contend that any other method of learning mathematics only tends to confuse and to impede learning, thus making it difficult for the child to learn the essential mathematical functions.

Therefore, based upon a review of related literature, a math-center (Piaget-based treatment group) was established within a self-contained classroom in the Roosevelt Elementary School. A control group was established in another self-contained classroom in the same school. The control group used the Addison-Wesley Elementary School Mathematics, 2nd Edition, Book 1. The treatment group used no text. The math curriculum emerged from the questions and needs of the children within the group.
The following hypotheses were tested:

The children in the treatment group will make greater gains in achievement than the children in the control group.

The high-ability child will make greater gains in achievement than the high-ability child in the control group.

The child with a visual-motor integration problem in the treatment group will make greater gains than the child with the same disability in the control group.

The child's placement on the Piagetian-based assessment of intellectual development will correspond positively with his post-test score on the Metropolitan Achievement Test.

All students were administered the math subtest of the Metropolitan Achievement Test (MAT)--Primary I and the Test of Basic Experiences (TOBE)--Mathematics--Level I as pre- and post-tests of math skills and experiences. These tests were given as pre- and post-tests.

All students were administered the Developmental Test of Visual-Motor Integration (VMI) to determine those with disabilities in the area of visual perception and motor coordination integration.

All students were given the Primary Mental Abilities (PMA) for Grades K-1 to identify those students having high-, average-, or low-ability.
All students in the treatment group were given an informal assessment of intellectual development (based upon the research of Piaget). Their re-evaluation with the instrument was continuous throughout the year.

The placement of students within the two groups was based upon the student's scores on the Metropolitan Readiness Test which was administered the previous spring. The five students with the lowest scores were placed in the treatment group. The remaining students were assigned by ascending scores, alternating, in the three first grades in the school.

The treatment group shows a greater growth in the understanding of basic mathematical concepts as determined by the TOBE, while the control group's score indicates a definite lack of growth in understanding.

The mean of the gained scores on the Metropolitan Achievement Test (MAT) shows greater gains for the control group, but not more than might be expected when consideration is given to the significantly higher mean of the IQ score for that group. Even so, the gained score of the low-ability students in the treatment group were greater than the mean of the gained-scores of the low-ability students in the control group.

The low-ability students made more gains than either the average- or high-ability students in the treatment group. Of course, it must be mentioned that many of the high-ability students were limited in gained-scores because of their high pre-test scores.
Though growth of understanding within the treatment group was significantly higher than the control group, the treatment group students also made substantial gains in computational skills and in reasoning ability. Their scores on the MAT were within reasonable range of the control group.

Even those students with a visual-motor integration (VMI) disability were able to grow in understanding of skills and concepts in the math-center approach. Their gains were significantly greater than any of the non-disabled in either group.

In total points gained the treatment groups' gained-scores were greater than the control group. The boys in the control group had gained-scores greater than the boys in the treatment group, but the girls in the treatment group had gained-scores greater than the girls in the control group.

The gained-score for the high-ability student was greater in the treatment group than in the control group. The same relationship was true for the average- and low-ability students. The group making the least gained-scores in the treatment and in the control groups were the high-ability students. High pre-test scores would not allow for substantial gains.

The VMI-disabled child in the treatment group made greater gained-scores than the VMI-disabled child in the control group. Within the treatment group the disabled child's gained-score was greater than child with average VMI ability and just less than the child with high VMI ability. Within the control group the gained-score of the VMI-disabled child was
greater than the child with average or high VMI ability. Across groups the VMI-disabled child's gained-scores average just slightly higher than the average of the children with high VMI ability. They were also higher than the average of the children with average VMI ability. In the treatment group the VMI-disabled boys had greater gained-scores than the girls. There were no disabled boys in the control group. The mean of the gained-scores of the disabled girls in the treatment group was double the mean of the gained-scores of the girls in the control group. When considering both groups, the disabled boys mean gained-scores are greater than for the girls.

There was a direct relationship between the level of proficiency in the assessment of intellectual development and the scores on the achievement tests for the children in the treatment group. This relationship was evident in both the pre- and post-test scores' comparison.

Conclusions

The math center approach to mathematics at the Roosevelt Elementary School appears to have been meaningful to all the first grade students who were enrolled in it. These children were able to learn math skills and concepts equally as well as the first grade students who were taught from a textbook.

Perhaps the most important finding of the study is shown by the significantly greater understanding of basic mathematics concepts which the
children in the treatment group exhibited. In the control group, five of the children actually scored fewer points on the post-test than on the pre-test. Only one in the treatment group did not improve his score. The control group teacher commented that her children could do math if it were something which they could memorize but if they had to figure it out they became stymied.

**Recommendations**

1) The writer strongly recommends the use of the assessment of intellectual development so the children can be presented mathematical challenges commensurate with their ability to comprehend. Only then can they progress without frustrations and unnecessary defeats.

2) The writer recommends that the early years' mathematics curriculum be relevant to the children's range of experiences and intellectual development. Also, they should be surrounded with objects to manipulate which they are encouraged to investigate fully and freely.

3) The writer suggests that similar studies be conducted before generalizations be assumed.

4) The writer also recommends that a random sample of treatment and control children be assessed at the beginning of the second grade and throughout the year to see if the relationship between intellectual development and successful understanding of mathematical principles continues to coincide.
BIBLIOGRAPHY


APPENDIXES
### CHART #2
(Continued)

<table>
<thead>
<tr>
<th>Name</th>
<th>Across from</th>
<th>On the same side as</th>
<th>Opposite from</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
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<td></td>
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Appendix B

Math-Center Materials

Sum Fun - Educational Fun Games

Smarty - Educational Ideas, Chicago

Sum Stick - Childcraft

Link Numbers - Milton Bradley

Attribute Blocks (Large and Pocket size) - Invicta Plastics, Ltd.

Perception Cards - Kenworthy Educational Services

Quizmo - Milton Bradley

Number Line (w and individual) - Milton Bradley

Early Stages (Numeral jigsaw puzzle) - James Galt and Co., Ltd.

Combinations Are Fun - Kenworthy Ed Services

First Arithmetic Game - Garrard Publisher

Hundred Chart (wall and individual) - Milton Bradley

Geoboard (be sure there is sufficient space between pegs)

Hundred Board

Fraction Discs - Milton Bradley

Cubical Counting Blocks - Ideal School Supply

Round pegs - Ideal School Supply

Modern Computing Abacus - Ideal

Judy Clock

Judy Magnetic Numbers
Magnetic Boards

Individual Mini-Judy Clocks

Lacing Boards (commercial and teacher made)

Dice (commercial and teacher made)

**Large Counting Sticks** - Ideal

**Counting Discs** - Addison-Wesley

Unifix Counters, Unifix Frames, Unifix Number Indicators

Individual Chalkboards

Ru for clock faces

Many, many teacher made games

**Hüsker Dů** - Regina Products, Inc.

**Aggravation**

Many commercial games are available

Ed-u-cards - many to choose from

Large and small counting frames

Scales

Balances

Rulers, tapes, yardsticks, string

Stopwatch

Bottles, jars

Beans, rice, etc.
VITA

Barbara Jean Knecht Eldredge

Candidate for the Degree of

Master of Education

Seminar Report: A Comparison of a Math-Center and a Traditional Program with First Grade Students in Roosevelt Elementary School

Major Field: Special Education - Learning Disabilities Emphasis

Biographical Information:

Personal Data: Born in Boston, Massachusetts, November 17, 1930, daughter of William Peter and Ora Knowlton Lee; married Burr Salmon Eldredge June 2, 1950; six children--Lloyd, Mikelene, Lamar, Jamie, Bryan and Barbara.

Education: Attended elementary schools in Cambridge and Lexington, Massachusetts, Wimbledon, England, and Shrewsbury, Massachusetts; graduated from Major Howard W. Beal Memorial High School, Shrewsbury, Massachusetts in 1948; attended Framingham State Teachers College, Framingham, Massachusetts and received the Bachelor of Science degree from Brigham Young University in 1952 with a major in Home Economics; completed requirements for the Master of Education degree, majoring in Learning Disabilities, at Utah State University in 1972.


Certifications:
Elementary, Secondary, Early Childhood, Learning Disabilities.