A CRITICAL EXPLORATION OF LEARNING STYLE PREFERENCES AND THE MATHEMATICAL ACHIEVEMENT OF CHAPTER 1 MIDDLE SCHOOL STUDENTS: ADMINISTRATIVE AND INSTRUCTIONAL IMPLICATIONS

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF EDUCATION
July 1993

OKLAHOMA STATE UNIVERSITY

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ACKNOWLEDGMENTS

I would like to express my heartfelt gratitude and appreciation to each of those individuals who helped me make this study a reality.

To Dr. Adrienne Hyle, your untiring support and direction in my doctoral program and my dissertation kept me going. You were always there when I had questions, doubts, or needed advice. Thank you for all the extra effort you gave to help me accomplish my goals.

To Dr. Margaret Scott, who encouraged me to pursue my doctorate, you have been a wonderful mentor, thanks for your guidance and inspiration and, most of all, for your friendship.

To Dr. Dorothy Finnegan, your continual guidance in the preparation and mechanics of writing this disseration was invaluable.

To Dr. Thomas Karman, you gave me the direction to always delve a little deeper and work a little harder.

To all my committee members, your philosophy that a student is a colleague was a refreshing stimulus to encourage me to always do my best.

To Dr. Robert Nelson, your assistance in computing and analyzing the quantitative data used in this study is deeply appreciated.

To Dr. Mark Spikell, your confidence in me encouraged me to grow professionally. I appreciate all you have done to help me.

To my husband, Bruce Peterson, your support, love, and belief in me kept me going, without you I could not have succeeded. Thanks for all your sacrifices, I can never repay you for all you have endured the past two years.

To my parents, J. Stanley and Florine Fullington Hall, you instilled in me the love of learning. Thank you for always encouraging me to be the best I can be and supporting me in all I have done.

To all those individuals who have guided me through my educational journey, I express appreciation and thanks.

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CHAPTER I

DESIGN OF THE STUDY

The winds of reform are blowing as evidenced by America 2000 and numerous state reform initiatives; the American public is disillusioned with public education and they are demanding accountability and change in education. Through this shift from public support, educators have begun to realize they may need to no longer require the student to conform to the structure of the school; the educational needs of the student may take precedence when developing today's educational program (Pellicer & Stevenson, 1991).

A crucial learning need that may have considerable influence on the success of a student in the educational environment is learning styles. Learning styles, "...the way in which each learner begins to concentrate on, process, and retain new and difficult information" (Dunn, 1991, p. 5), are important because not all students learn the same way. Teachers have failed to recognize this. This failure is indicated by the number of students who earn failing grades in their journey through the school system, by the number of students who are considered at-risk of failure or attrition, and by the number of students who just drop out of the system (Usiskin, 1989).

Teachers teach the way they were taught, which was primarily through lecture and independent desk work (Lawson, 1990). In terms of learning styles, this method reaches only those students with an auditory strength (Dunn, 1991). In addition, most classrooms have rows of desks neatly aligned, with bright lights, quiet, and very little student movement. This is no longer only appropriate classroom design (NCTM, 1989; Center, 1992). Research indicates the learning style strengths of only a minority of students have been supported by these traditional methods and classroom design (Dunn, 1991). Teachers must teach to every student, impacting both the cognitive and affective domains, taking into consideration the learning styles of all students (Everybody counts, 1989; Dunn, 1991). Only in this way can educators reach all students so *all children can learn* (Taylor, 1992). All students can learn but most students learn best when they learn their way.

Those students who are successful in adapting to the traditional methods of teaching usually succeed in school and frequently are placed in accelerated classes, gifted programs, and advanced placement.

> It (a middle school math classroom) was pretty much teacher-directed, passive learning. Kids who did well were the ones you'd expect to do well--kids who are pretty good at procedures, who are able to sit still, who are able to learn concepts in a fairly abstract way. (Smith, Smith, & Romberg, 1993, p. 4)

On the other hand, students who do not adapt effectively to the traditional classroom frequently experience failure and often are placed in remedial programs. One such program is Chapter 1, a federally supported program of compensatory education for educationally-deprived students (Doyle & Cooper, 1988). These students are "children whose educational attainment is below the level that is appropriate for children of their age" (U. S. Department of Education, 1990, p. 59).

Statement of the Problem

Students are categorized from the moment they enter public education. Although early categorization might be as innocuous as blue birds and robins, the students are quickly initiated into the placement paradigm that follows them throughout their schooling. Categorization becomes more prevalent as the students progress from elementary school into secondary school. By then the students have been evaluated in terms of intelligence quotient, academic ability, socialization skills, self-control, and academic potential and achievement. All too often, placement in classes and availability of services and opportunities will be decided on the basis of these evaluation factors (Wheelock, 1992).

Evaluation placement is often based entirely on standardized test scores (Kennedy, Birman, & Demaline, 1986). But, standardized test scores are not necessarily reflective of student ability. Several factors, such as motivation, emotional reactions, situational problems, and maturation affect the performance of a student and result in inaccurate evaluation outcomes, especially of those who score low. The students may have "played" (marked answers indiscriminately) on the test, not applying themselves to the task at hand. Other unmotivated students have not any completed the test to the best of their ability. Some students suffer from test anxiety and consequently score poorly on standardized tests. A history of poor attendance may have contributed to gaps in their mathematical or reading background. Slow learners, though they will eventually learn, are behind at this juncture due to a maturation lag. Many students do not function well in the traditional classroom when they have to remain quiet, cannot move, and are uncomfortable in school desks. They will not only have more difficulty learning the material on which the test is based but will be further handicapped by a standardized test which requires strict and rigid test administration procedures.

As a middle school Chapter 1 mathematics teacher, I observed that many students who qualified for Chapter 1 services after having been identified as below grade level in achievement were actually capable or had the ability to succeed in mathematics. Further observation indicated that these students performed well in areas that were not emphasized in the traditional middle school classroom or assessed through standardized achievement tests, such as geometry and spatial visualization activities, recognized as "right brain" activities (Springer & Deutsch, 1989). Many of the students also functioned better with an approach to teaching mathematics that included an informal classroom design, and activities which were spatially-oriented as opposed to those that were linear and sequentially organized. These observations and experiences led me to question whether the Chapter 1 students differed in learning style from other students who, as determined by standardized test results, achieved better in mathematics and did not qualify for Chapter 1. Further, I wanted to explore the possibility that these differences led to their placement in Chapter 1 and ultimate lack of academic success in mathematics?

Purpose

The purpose of this study was to examine the relationship between achievement and learning styles of middle-level students. Specifically, the study sought to explore three related areas within this relationship.

1. the quantitative correlation between learning styles and mathematical achievement;

2. the quantitative determination of significant differences in the learning styles of students whose test scores indicated lower levels of mathematical achievement (i.e., Chapter 1 students) and those students whose test scores indicated a higher level of mathematical achievement; and

3. the qualitative exploration of relationships between students' perceptions and learning styles through interviews and observation.

Given these findings, the final purpose of the study was the generation of advice for practice which would include implications for curriculum and/or administrative modifications in mathematics programs, student assignment to those programs and programmatic classroom design.

Research Objectives

To accomplish the purpose of this study the following seven research objectives were used:

1. To identify the learning styles of middle school students.

2. To identify the mathematics achievement of the same middle school students.

3. To examine the correlations between middle school students' learning styles and their mathematical achievement.

4. To determine if there were a statistically significant difference in the learning styles of Chapter 1, average achieving and high achieving middle school mathematics students.

5. To determine, through teacher observation and student interviews, if the statistical findings were consistent with student behavior and perception.

6. To discuss the implications of these findings in design of and student assignment to mathematics programs from both administrative and instructional perspectives.

7. To generate advice for practice.

Conceptual Framework

To understand the framework for learning styles, one must look at the influences of major learning theorists in the twenty-first century. Dewey (1938), an advocate of experiential education, maintained "experiences in order to be educative must lead out into an expanding world of subject-matter,"... a condition satisfied "only as the educator views teaching and learning as a continuous process of reconstruction of experience" (Dewey, 1938, p. 87). Piaget supported constructivism, believing that learners construct their own knowledge (Vuyk, 1981). Similarly, Bruner (1977), a proponent of discovery learning, believed that students must discover for themselves the generalizations that lie behind a concept. From a different perspective comes Skinner (1954) who proposed that given a stimulus, a response would occur; if the response were correct and the individual was given positive reinforcement, learning would occur. Gagné (1965), another behaviorist, supported programmed learning, a system in which the material to be taught is divided into components that are chained together in a logical sequence.

These 20th century theorists can be divided into two rather distinct paradigms, or groups: experientialists and behaviorists. While Dewey, Piaget, and Bruner focused on the individual and learning, advocating the student's involvement in the process, Skinner and Gagné were more concerned with training the student; procedure was more important than process. Though elements of learning styles are encompassed in the experiential theories of Dewey and Piaget, learning styles are not dealt with directly by any major learning theorist. The elements of learning styles were never components of a delineated theory which was recognized until the 1970's (American Association of School Administrators, 1991).

The National Association of Secondary School Principals defines learning styles to be "characteristic cognitive, affective, and physiological behavior that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Keefe, 1987, p. 5). The focus of learning styles is on the individual (Guild, 1990). Several models of learning styles have been developed including those by Kolb, McCarthy, Gregorc, Witkin, Jung and Dunn and Dunn (Guild & Garger, 1985).

The most widely used learning styles model was developed by Rita and Kenneth Dunn. The Dunn and Dunn model focuses on environmental, emotional, sociological, physical, and psychological stimuli which impact student learning. Through a self reporting inventory, information is provided about the factors which influence how students acquire and process material. The large body of research using the Dunn and Dunn model has contributed information, knowledge, and insight concerning the learning styles of students (Guild & Garger, 1985).

Significance of the Study

Traditional learning theory has never taken into consideration the learning styles of students (Cruikshank & Sheffield, 1992). In behaviorism, individual student learning styles were not given consideration. Rather, if a stimulus were introduced to the student a concomitant response would be expected and reinforcement forthcoming if the response were correct (Skinner, 1954). This theory embodied the underlying idea that all factors could be controlled. Constructivism has given more credence to individual learning styles though they are not addressed specifically; by letting students construct their own knowledge they are given the opportunity to work within their own learning style preference (Bybee & Sund, 1982). Therefore, allowance is made for extra factors.

Though low-achieving and at-risk students have been considered in research using the Dunn and Dunn model, the specific category of Chapter 1 students has not been addressed. Research results from this unique classification of Chapter 1, which involves not only academic achievement but economic and sociological status, may contribute new information to learning style theory.

Research on the Dunn and Dunn (Dunn, 1991) model of learning styles indicates that students' learning style significantly affect their success in school. Lecture, formal design, and immobility have predominated in the traditional school setting. The learning styles of students who have succeeded in the traditional school setting have accommodated these methods. This study extends the research on the Dunn and Dunn model by focusing on Chapter 1 students and their learning styles. This study will clarify and augment learning theory as it is reflected in learning styles and should indicate which modifications in instruction and classroom design will help Chapter 1 students achieve success in school.

If the results of this study indicate that the learning styles of those students who are identified as Chapter 1 differ significantly from those of other students placed in regular and advanced programs, the implications for administrative practices include the question of placement for students based solely upon standardized test scores, the learning theory approach of teachers for students of different achievement levels, and the effect of learning styles on a student's success in school. School personnel may need to consider alternative methods of evaluating children's progress and ability for placement in various academic programs. Should the results of this study indicate Chapter 1 mathematics students have a tendency toward specific learning styles that are enhanced by a specific theory of learning, more mathematics teachers may be encouraged to reflect this conclusion in their classroom instruction. And finally, should definite differences in learning styles for students in Chapter 1, regular, and advanced programs be discovered, they may indicate a change in administrative policy regarding testing environments, classroom management, teacher assignment, and scheduling.

Methods other than teaching to the test and remediation must be found which will stimulate all children to reach their full potential. Identifying the learning styles of Chapter 1 students and implementing a program which addresses these learning styles may be one answer. If a student's learning style indicates a preference while learning difficult material and this preference is accommodated in the classroom, the student may take a more active interest in learning. Success breeds success. Once a student realizes s/he can achieve, this may serve as the motivation for continued success.

Procedures

The following section presents an overview of the procedures used to execute the study, including data needs, population and sample, the data collection methods, and the data analyses. Operationalization of these procedures will be provided in Chapter 3.

Data Needs

The research objectives posed by this study required data from four sources: a measure of the mathematical achievement of the students, an inventory of the learning styles of each student, and information about and from selected students and observation regarding their perceptions of their learning style and classroom experiences.

The total mathematics score from the Iowa Test of Basic Skills was used as a measure of mathematics achievement. The Dunn and Dunn Learning Styles Inventory profile was used to determine the learning styles of each student (Dunn, Dunn, & Price, 1989a). Student perceptions were determined through classroom observations and semi-structured interviews.

Population and Sample

The population for this study was all regular classroom students enrolled in one urban middle school, grades 6 - 8, in a large metropolitan school district in a southwestern state. The sample consisted of students in that school for whom there was a total mathematics score from the Iowa Test of Basic Skills (ITBS) and a Learning Style Inventory (LSI).

Quantitative Methods

All students enrolled in this middle school as of the 21st of September, 1992 had been given the Dunn and Dunn LSI through their reading class. To acquaint the students with learning styles prior to the administration of the inventory, the video "The Look of Learning Styles" was shown because students who have some understanding of learning styles achieve greater consistency in reporting their own learning styles (Dunn, Dunn, & Price, 1989b). These inventories were machine scored at the county superintendent's office. The results were returned to the school in the form of student profiles and coded into an archival data base program.

The ITBS was given to all students at the middle school in the spring of 1992. The students were divided into three groups based upon their ITBS total mathematics score: Chapter 1, students who had a percentile score of 35 or lower; average achieving, students who had a percentile score within the range of 36 - 64; and high achieving, students who had a percentile score of 65 or above. On the learning styles inventory, only the data from those students who had a consistency score of 70 or above were used. This consistency score was necessary for meaningful results (Dunn et al. 1989b). The students' total mathematics score from the ITBS was correlated with the standard score for each student on five select subscales of the LSI, (noise level, light, design, intake, and mobility) to determine if there were a linear or discernable relationship between student mathematics achievement and learning style preferences.

An analysis of variance was run to determine if there were a significant difference between the mathematical achievement students identified as Chapter 1, average, and high and their learning style preferences for the five select subscales of the LSI.

Qualitative Method

A small sample of students were selected for interviews. Since the literature indicates that students with low achievement would prefer sound, low light, informal design, intake, and high mobility, the student preferences on these five subscales were used to determine if the learning style profile was consistent with mathematics achievement. Both students whose mathematics placement in Chapter 1 was inconsistent with their learning style preference and those whose placement in Chapter 1 mathematics was consistent were selected. In addition, some students who were not Chapter 1 eligible were selected to determine if their perceptions differed from those of Chapter 1 students. A set of semi-structured questions, about perceptions of learning styles, coping strategies, and awareness of factors which contributed to their success comprised the interview protocol (Appendix C). These data were categorized and inductively reconceptualized into emergent themes.

Summary

Traditionally, students have been taught in a formal classroom setting through the use of lecture, drill and practice, and objective evaluation. There is evidence through learning theory and learning style research, that not all students will achieve to their potential in such an educational setting. This study, using both quantitative and qualitative methods, was devised to explore the relationships between the learning styles of middle school mathematics students and their placement in Chapter 1, regular, or advanced mathematics programs. These results were analyzed to reveal the administrative and instructional implications arising from those findings in an effort to provide the most appropriate education and opportunities for success for all students.

Reporting

This chapter has presented the design and rationale of this study. In the next chapter, the theoretical and research base for this study will be examined. In Chapter III the data will be presented. The analyses and interpretation of the data will be presented in Chapter IV. Chapter V will include the findings, summary, conclusions and recommendations.

CHAPTER II

REVIEW OF LITERATURE

The purpose of the study was to examine the correlation between the learning styles of students and the students' mathematical achievement of middle level students; to determine if there were significant differences in the learning styles of Chapter 1 students and those students whose test scores indicated a higher level of mathematical achievement; and to explore, through interviews and observations, students and their learning styles. This chapter will include a description of the theoretical framework for learning styles and examine the research which has been conducted in the area and an overview of the Chapter 1 program including identification of at-risk students, the characteristics of middle school students, learning theory and learning styles as they relate to mathematics education, and mathematical assessment.

The Chapter 1 Program

This section will present a historical overview of the Chapter 1 program, the definitions of at-risk students within those programs, the process of identification of students for the Chapter 1 program, and the evaluation of students in the Chapter 1 program.

Chapter 1, a federally supported program of compensatory education for educationally deprived students, is the largest federal aid program to elementary and secondary education (Subcommittee, 1985). As such, it has tremendous impact on the education of hundreds of thousands of students yearly. The Declaration of Policy for Chapter 1 recognizes that these children have special educational needs (Subcommittee, 1985). It is my contention that one of these needs involves learning styles; that many students who have been identified as needing Chapter 1 services would achieve better if mathematics were taught to their learning style.

Authorization for Chapter 1 funds, however, does not require a particular instructional program. "Districts and even schools within districts differ in the grade levels they serve, the procedures they use to select students, the services they provide, and the administrative strategies they use to orchestrate these services" (Kennedy, Birman, & Demaline, 1986, p. 1). In other words, school districts are permitted to design the program they believe will foster the educational development of their specific population of students. This specific population, Chapter 1, are identified as needing additional instruction in academic subjects, in most school districts, nationally, by scores from a standardized test (Subcommittee, 1985).

Historical Perspective

The social conscience of the American people awakened in the 1950's and 1960's to the fact that many children were not receiving an adequate education (McDill, McDill, & Sprehe, 1969). Many of these children were from low income areas where political influence and monetary means were not prevalent. Consequently, the parents of these children did not have the financial or political resources to demand money be spent on the education of their children. Middle class parents, who supported the tax base and were politically influential continued to demand that their tax monies be spent on their children rather than disproportionate amounts being spent to educate those children who were considered *educationally deprived* (Subcommittee, 1985).

With this background, in 1965 Congress enacted Title I of the Elementary and Secondary Education Act. Title I's Declaration of Policy described the law's purpose as follows:

> In recognition of the special educational needs of children of low-income families and the impact that concentrations of low-income families have on the ability of local educational agencies to support adequate educational programs, the Congress hereby declares it to be the policy of the United States to provide financial assistance (as set forth in this title) to local educational agencies serving areas with concentrations of children from low-income families to expand and improve their educational programs by various means (including preschool programs) which contribute particularly to meeting the special educational needs of educationally deprived children. (Subcommittee, 1985, p. 15)

Title I is an educational program "... designed to compensate--to make up for some putative deficiencies in a person's learning experiences.... Compensatory education has been aimed at modifying the behavior of the individual so that he [sic] can better survive in the educational system or at altering the system so that it will be more successful with students having special difficulties" (McDill, et. al, 1969, p. 1).

In 1981, Congress modified Title I by enacting Chapter 1 of the Education Consolidation and Improvement Act (Subcommittee, 1985). It recognized that fundamental conditions which made Title I necessary continued to exist. Chapter 1's Declaration of Policy was:

> to continue to provide financial assistance to meet the special needs of educationally deprived children, on the basis of entitlements calculated under Title I of the Elementary and Secondary Act of 1965... Further, Congress recognizes the special educational needs of children of low-income families, and that concentrations of such children in local educational agencies adversely affect their ability to provide educational programs that will meet the needs of such children.... (Subcommittee, 1985, p. 16-17)

Under Chapter 1, local school districts must identify educationally deprived children, determine in which grades and subjects Chapter 1 services are most needed and develop programs to help these children catch up with their peers.

At-Risk Students

Many titles have been given to students who are provided Chapter 1 services. Throughout most government documents, these children are referred to as educationally deprived, "children whose educational attainment is below the level that is appropriate for children of their age" (U. S. Department of Education, 1990, p. 59). In the literature, they have been referred to as culturally deprived, socio-economically deprived, socially deprived, socially disadvantaged, and educationally disadvantaged (Gordon & Wilkerson, 1966; Passow, Goldberg, & Tannenbaum, 1967; Natriello, McDill, & Pallas, 1990; LeTendre, 1991). Within the past few years, the new term, "at-risk" students, has been applied to these same Chapter 1 participants.

At-risk students are those who are most likely to fail school or drop out (Johnson, 1990). They are considered in "danger of failing to complete their education with an adequate skill level" (Slavin & Madden, 1989, p. 4). Other students whose needs are not being met in the school system are included in this classification (Bryant, 1991). Regardless of what classification is used, these students do not perform well in the average classroom and usually have a very low concept about their academic performance.

Participant Identification

The federal government allocates monies to states which in turn distribute the monies to local districts or Local Education Agencies based upon "counts of low-income children derived from census or National School Lunch Program data" (Subcommittee, 1985, p. 17). Chapter 1 programs may only be administered in "eligible schools" within the district. "This means, with certain exceptions spelled out in the 1983 Technical Amendments to Chapter 1, schools with a higher-than-district average number or percentage of low-income children" are eligible (Subcommittee, 1985, p. 17).

Within the district, those students who demonstrate the greatest level of educational deprivation must be targeted for Chapter 1 services (Subcommittee, 1985). The school district must identify these students, determine in which grades and subject areas services are most needed and develop programs to help these children catch up with their peers (Subcommittee, 1985). Many districts use the National Curve Equivalent (NCE), an equal interval percentile rank used to aggregate numbers as a substitute for a standard score, to determine eligibility. For the purposes of this study, Chapter 1 mathematics eligible students were identified as any student whose total mathematics NCE on a norm-referenced standardized test was 42 or lower.

Program Evaluation

"...Chapter 1 requires districts to evaluate the effectiveness of their federally-funded compensatory programs by a set of methods that includes objective tests of the students' achievement in their basic skills (Subcommittee, 1985, p. 18). Common practice is to use a nationally standardized achievement test such as the Iowa Test of Basic Skills as the evaluation instrument. The progress made by the student from the pretest to the posttest becomes the measure of effectiveness of the program.

Assumptions are made about Chapter 1 students in determining their progress during the year. The first assumption is that as students normally progress through the school year without Chapter 1 assistance they would have the same rank at the end of the year as they did at the beginning. Second, students not participating in Chapter 1 programs who are the same percentile rank are comparable to Chapter 1 students. Research has found though Chapter 1 students experience larger increases in their test scores on standardized achievement tests, these gains do not move them substantially toward the achievement levels of advantaged students. In actuality this may not reflect on the program or the students since standardized tests do not measure higher order skills, spatial perception, or mathematical application and communication, skills which are emphasized in many Chapter 1 mathematics programs. Nor do they "reflect the long term consequences of Chapter 1 program participation, and they only imperfectly measure the basic reading and mathematics knowledge they are designed to assess" (Kennedy, et al. 1986, p. 4).

Summary

The Chapter 1 program is the "largest single program of federal education aid to elementary and secondary school students, accounting for about 22% of the entire Department of Education budget" (LeTendre, 1991, p. 578). This program provides additional educational services for those children who are identified as educational disadvantaged.

In the next section the characteristics of middle school students will be presented.

Characteristics of Middle School Students

The middle school concept recognizes the necessity of transition between elementary school and high school (George, Stevenson, Thomason, & Beane, 1992). Most middle schools are composed of grades six through eight. Students in these grades usually range in age from 11 through 14. These pre-teen, early adolescent years are tumultuous ones, characterized by increasingly complex physical, cognitive and emotional changes (Stevenson, 1992).

Physical

The physical transition from childhood to adulthood occurs during adolescence. Growth spurts are characteristic and the subsequent developmental changes frequently leave students feeling self-conscious about their bodies. The physical changes experienced during this period are "so variable and uncertain that adults must be especially sensitive to kids' body image concerns during early adolescence (Stevenson, 1992, p. 86).

Sequential development is the same for all children though rates of development vary. In girls, who generally develop eighteen months to two years before the boys, these changes are characterized by an "initial growth spurt in height accompanied by a gradual redistribution of body fat and breast budding" (Stevenson, 1992, p. 86). These girls are being transformed into womanhood, and physical appearance becomes very important. As girls are moving out of their growth period into a declining rate of development, boys are at or near the height of their changes. These changes include "increased height, and more masculine-shaped shoulders, back, hips, and limbs", more pronounced musculature, voice change, and facial hair (Stevenson, 1992, p. 88). As with girls, the differing rates of development can be very unsettling for the boy who is much smaller than other boys in his class.

Cognitive

Brain growth spurts occur between the ages of 10 - 12 and 14 - 16. Each spurt is followed by a plateau. Herman Epstein has hypothesized that during growth spurts, left-brain processes can be most effectively learned. Right-brained processes are then best acquired during the plateaus. Epstein also found that gender differences existed in cognition. The girls experience a major growth spurt between the ages of 10 - 12 while this spurt occurs in boys between the ages of 14 - 16 (Cornett, 1983). Left-hemisphere specialization may then develop in girls at a younger age than boys. Girls were also found to be inferior in spatial visualization. If the hypothesis that left-brain processes are most effectively learned during growth spurts, it may account for the earlier left-hemisphere specialization in girls and the inferior development of right-hemisphere processes. These gender differences clearly influence the learning styles of middle school students.

According to the stages formulated by Piaget, most middle school students would be in the formal operational stage (11 - 15 years). In the formal operational stage, the student would be able to form concepts abstractly rather than from concrete experiences. But as Piaget maintained, not all students reach each stage at the same chronological age. Consequently, the middle school student may be at the concrete operational level (7 - 11 years) where s/he "begins to internalize actions with concrete operations" (Dutton & Dutton, 1991, p. 22). In addition, some students who are at the formal operational level for some mathematical concepts may need to approach new concepts from the concrete operational level (Bybee & Sund, 1982).

Emotional

The physical changes which occur during adolescence create a great deal of emotional turmoil for middle school students. In addition to the differing developmental rates, these children are dealing with hormonal changes which occur with their developing sexuality. They are curious about changes both in their own bodies and those of the opposite sex. The different orientations toward sex between girls and boys at this age further adds to the emotional rollercoaster. While most girls have a romanticized view of sex, boys tend have a more carnal interest (Stevenson, 1992).

School becomes a social event for middle school students. They are beginning to express their independence from their parents. This period "marks a transition from parents as the ultimate authorities in youngsters' lives to peers and the peer group as the primary influence (Stevenson, 1992, p. 101). Family discord may occur during this time creating a greater need for emotional support from other sources. They form social groups at school which may change daily with the impulsive nature of their emotional attachments.

Summary

Teaching the middle school student requires not only knowledge of their physical, cognitive, and emotional needs but also knowledge of how these students learn. The next section will focus on learning theory.

Learning Theory

Students do not learn by virtue of simply being exposed to material. There are numerous theories postulated which give some insight to the ways in which children learn and the best instructional strategies for imparting knowledge to children. Two of the most prevalent learning theories in modern education are those espoused by the developmentalists or constructivists and the behaviorists. This section will focus on these major learning theories.

Constructivism

Constructivism is a broad term which includes those theorists who believe the student is an active agent in her own learning. The constructivist model for teaching and learning mathematics is based in the developmental theories of Piaget. Through extensive interviews with children, Piaget formulated four stages of development through which children pass in their maturation. He divided these into two major components, pre-logical and logical (Bybee & Sund, 1982).

Pre-logical. Two stages encompassed in pre-logical development, according to Piaget, are sensori-motor and pre-operational. The first developmental stage, sensori-motor, occurs from birth to the age of two years. During this period the child experiences coordination of physical actions and is pre-verbal and pre-representational. The period from two years to seven years is the pre-operational period which is characterized by the ability to represent action through thought and language. During this period the child's reasoning is intuitive.

Logical. The stages of the logical component are concrete operational and formal operational. The third developmental stage begins around the age of seven as the child enters the concrete operational stage, characterized by logical thinking based in physical reality. The last stage, formal operational, occurs from 11 to 15 years of age when the child begins logical thinking, abstract and unlimited. Each stage builds upon the previous stage, integrating earlier understandings into later stages at higher levels of organization (Labinowicz, 1985).

Piaget believed that all children developed in the same sequence of stages of learning but at different rates. One 12 year-old may be at the formal operational stage while another is still at the concrete operational stage. Children may also be at different levels for different concepts. A child may understand basic arithmetic operations at the formal operational stage but need to employ the concrete operational stage when first learning algebraic concepts (Bybee & Sund, 1982).

One of the importance of these stages is to give some foundation for determining the appropriate time for introducing mathematical concepts to children. The constructivist model advocates that children must construct their own knowledge for it to be meaningful and they are unable to do this if they are not developmentally ready. Since many mathematical concepts build upon previous knowledge, it is imperative for continued understanding that the child understand each concept before progressing (Kamii, 1985).

Piaget maintained that a child must act upon knowledge and transform it to learn. This process has been referred to as equilibration. There are four processes involved: assimilation, accommodation, disequilibrium, and equilibrium. As a child encounters new knowledge s/he may assimilate it with previous knowledge or s/he may realign what s/he knows to fit in the new knowledge. Disequilibrium occurs when the inner balance is upset by the new knowledge; it does not fit with prior knowledge and throws the child "off balance" intellectually. This is a very important step in constructing the new knowledge. When the child has interacted with the new knowledge and understands it and internalized it, inner balance, or equilibrium occurs. The child has constructed her own mathematical knowledge and understands it. Through this continual process knowledge is constructed and developed (Labinowicz, 1985).

Piaget also enumerated three types of knowledge: social (conventional), physical, and logico-mathematical (representational). The first two are external. Social knowledge refers to conventions established by society, such as November 11 observed as Veteran's Day. Physical knowledge refers to knowledge about objects in the environment, directly obtainable from the objects themselves. For instance, a child can discover the size, color, shape, texture of a block from explorations and direct observation (Labinowicz, 1985). The last, logico-mathematical holds the most importance for constructivism. This knowledge is internal and is a mental representation. The child manipulates these representations internally to construct knowledge (Kamii, 1985).

The implications of this model for the classroom are overwhelming. To allow a child to construct her own knowledge rather than become a receptacle for unrelated facts flies in the face of the traditional mathematics classroom. It encourages moral autonomy by encouraging the child to think for herself, to problem solve, and to make decisions based on her knowledge. It provides for learning to occur which is developmentally appropriate. Children can be at different levels within a stage for different types of learning. Until the child is ready, however, knowledge cannot be constructed and learning will not occur. The teacher is no longer an "instructor" disseminating information but a "facilitator" guiding discovery. Children are guided into equilibration without being overwhelmed by material for which they have no experience on which to draw. Knowledge is internalized because it has connections (Labinowicz, 1985).

The concrete operational level is important in mathematics achievement since many of the operations at this level are mathematical in nature. Included in this stage are "classification, ordering, the construction of the idea of number, spatial and temporal operations, and all the fundamental operations of elementary logic of classes and relations of elementary mathematics, of elementary geometry and even of elementary physics" (Copeland, 1984, p. 409).

This theory contends that children learn better when they are active agents in their own learning. Only when a student acts upon something and changes it does the student learn. Later the student may reflect on the actions to construct ideas. Coordination of these ideas with other existing ideas may eventually occur at a higher level of understanding (Labinowicz, 1985).

Children enter the classroom with previous experiences: cultural, social, and physical. These experiences influence the learning experiences of students. Students apply their personal interpretation to that which is presented. For each common experience there are as many different meanings as there are children in the classroom and they influence how children construct their own learning. Labinowicz (1985) states that we need an understanding of the existing views of children before we can undertake teaching them in any new content area.

Behaviorism

B. F. Skinner's theory of behavioristic positive reinforcement has also influenced educational practices in the area of learning (Skinner, 1954). In contrast to Piaget, Skinner's definition of learning reflects a response, not understanding. According to Skinner, shaping or changing behavior results from application of immediate positive reinforcement to the behavior sought. Skinner maintains that a lapse of even a few seconds between the response and the reinforcement can destroy the effect. For example, when a student gives a correct answer to an arithmetic fact, a smile or word of praise would be positive reinforcement which would encourage the student to want to give correct answers. This would be the motivating factor behind children learning basic facts. As students learn the basic facts they should be given positive reinforcement consistently and continually; when the facts have been learned, the reinforcement should be given intermittently to maintain the skills. Punishment or blame should not be used since it does not have long-term effects on changing behavior and can have negative effects (Sovchik, 1989).

Skinner contended that one of the most serious criticisms of classroom instruction was the lack of immediate and frequent feedback for students. In an effort to alleviate this problem, he developed programmed instruction through teaching machines. The student would receive immediate feedback from the machine and reinforcement for the right answer (Skinner, 1954).

The impact of behaviorism in the classroom and on theories of learning has been substantial, particularly in mathematics. "The hierarchical nature of mathematics makes it a popular candidate for a behavioral approach" (Reyes, Suydam, & Lindquist, 1989, p. 46). This is evident in the behavioral objectives which predominate mathematics textbooks and programmed instruction which dominated early mathematical software.

Summary

The two predominate learning theories in mathematics education are constructivism and behaviorism. There is a shift from an emphasis on behavioristic theory as a basis in mathematics education to constructivism. One basic difference is the distinction between product (behaviorism) and process (constructivism). Behaviorists believe there is a body of knowledge, external to the student, which must be imposed upon the student. In contrast, constructivism contends the student is not an empty box to be filled but rather the student constructs her own knowledge (Copeland, 1984).

Learning theory has considered only the cognitive development of the student and has not focused on other factors which may influence learning (Bruner, 1977). The next section will focus on learning styles, another factor which is believed to influence learning.

Learning Styles

The definition of learning styles developed by the National Association of Secondary School Principals states: "Learning styles are characteristic cognitive, affective, and physiological behavior that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Keefe, 1987, p. 5).

Rita Dunn defines learning style as "a combination of many variables which contribute to learning, each in its own way and all working together as a unit" (1991, p. 5). She further states: "Learning style, then, is the way in which each learner begins to concentrate on, process, and retain new and difficult information" (Dunn, 1991, p. 5).

There are three approaches to learning styles. The first focuses on personal awareness, yourself and the person with whom you are dealing. This approach is found in Gregorc and Jung. An application to curriculum design and the instructional process is characteristic of Kolb and McCarthy. The Dunn and Dunn model is a diagnostic/prescriptive model which matches instruction to individual differences (Guild, 1990).

According to a survey of American Association of School Administrators members twice as many responded that they considered learning styles very important. When asked what major approaches were used in classrooms 23% of the respondents indicated the Dunn approach was used in classrooms in their schools. This compared to 16% who used the 4MAT approach advocated by McCarthy and 8% who used Gregorc (American Association of School Administrators, 1991). Since this paper focuses on the Dunn and Dunn model of learning styles, the other models will be presented first.

The 4MAT Model

David Kolb, a management expert from Case Western Reserve University theorized that people approached learning through "feeling" or through "thinking" (AASA, 1991). The way people perceived and then processed what they perceived resulted in their learning. He found that people perceived either through concrete experience or through abstract conceptualization. Their processing occurred either through active experimentation or reflective observation. From these ways of perceiving and processing he developed a four quadrant model of learning styles. Appendix A contains a model of the Kolb circle.

Kolb characterized each style of learner as follows:

- imaginative learner - integrates experiences, seeks personal involvement, reflective, sees all aspects of a problem, people oriented;

- analytic learner - perceives information abstractly, makes connections with what is known, sequential thinkers, detailed, engrossed in ideas;

- common sense learner - integrates theory and practice, practical, cuts through immaterial, likes to experiment; and

- dynamic learner - integrates experience and application, flexible, risk takers, intuitive, likes change (AASA, 1991).

In the late 1970's, Bernice McCarthy, an experienced educator, developed an approach to exploring learning differences and styles based on a synthesis of a variety of learning styles models. Using Kolb's model and integrating the work of other learning style theorists, she developed the 4MAT Model. McCarthy defined the learners as perceiving either through concrete experiences or abstract conceptualization and processing through reflective observation or active experimentation. She further explored how each learner would be affected by the processing of the right and left hemisphere. Breaking each quadrant down into right and left hemispheric specialization, she refined the Kolb circle into the 4MAT model which encompasses an eight step process for teaching. Appendix A contains a model of the 4MAT quadrants.

Beginning in the upper right quadrant step 1 creates an experience for the right mode of the innovative learner. Step 2 should reflect and analyze the experience. Moving into the lower left quadrant, step 3 for the right mode integrates reflective analysis into concepts while step 4 develops the concepts. Step 5 for the common sense learner in the right mode is to practice defined givens. Practice and the addition of something of oneself completes the lower left quadrant. For the dynamic learners, step 7 analyzes application for relevance and usefulness in the right mode. The final step requires the learner to do it and apply it to a new and more complex situation (AASA, 1991).

McCarthy believed that all learners should start in quadrant one and progress through the four quadrants in order. In this way the questions of why, what, how, and if will be addressed and each type of learner will have an opportunity to shine part of the time (AASA, 1991).

Gregorc's Model

A second learning style approach, developed by Anthony Gregorc, encompasses the model of perceiving either concretely or abstractly. He describes the mind as exhibiting the ability to order information and knowledge rather than using the term "processing." This continuum ranges from sequential ordering to random ordering (Guild & Garger, 1987).

Combining the two types of perceiving with the two types of ordering, Gregorc identified four learning styles: concrete sequential, abstract sequential, concrete random, and abstract random. Concrete sequential learners desire direct, hands-on experience, with order and logical sequence in the presentation. Concrete random learners are intuitive with an experimental, trial and error attitude. Abstract sequential learners think abstractly, preferring to learn through reading and listening. They like order. Abstract random learners prefer to receive material in an unstructured manner, evaluating the experience globally (Claxton & Murrell, 1987).

This model uses the quadrant grid without the connecting circle of the 4MAT. Results from the Gregorc Style Delineator are plotted to produce a four pointed shape. A strong preference for one style will cause the point to fall further from the origin on the axis for that style. The resulting shape indicates the relationship between the four styles for the individual. Though one style will be predominate, each person will have characteristics from each style (Guild & Garger, 1985).

Though both the 4MAT and the Gregorc model are similar in their format, the 4MAT model focuses on instructional delivery, the Gregorc model concentrates on how the student perceives information.

The Myers-Briggs Model of Personality Types

Carl Jung believed that people develop comfortable patterns and behave in certain ways which can be classified into four mental processes and two attitudes. These function as opposites on a continuum. The resulting personality types affect personal and professional life to which Jung insisted no value be attached. In other words, no one type was better or worse than another (Lawrence, 1982).

The first mental process can be characterized as how we become aware of things and events. People who use their senses, sight, hearing, smell, and touch, to take in information are *sensing* (S). For them seeing is believing, they rely on the information which is real and observable. They trust what they can observe through their senses. On the other end of the continuum is *intuition* (N). Intuitives rely on images that their mind creates based on information which they take in. They read between the lines, attending to the meaning of what is said. They search beneath and beyond reality, distrusting surface information. This leads them to a focus on what is and what might be (Myers, 1980).

The next process affects the way we process information and come to conclusions about what we perceive. *Thinkers* (T) analyze information, data, situations, and people to make decisions. They are analytic, applying logic before drawing conclusions. Thinkers are thought of as objective, cool, calm, and collected. In fact their thoroughness can cause them to be thought of as slow. They trust objectivity, data, logic, and rational arguments. On the other hand those who approach decisions subjectively, emotionally, and perceptively are classified as *feeling* (F). They weigh the effect of decisions on themselves and others. Consequently their decision making processes are not totally objective. They live in a world of gray where "it depends" becomes a standard answer (Myers, 1980).

The final area which was developed and described by Jung is our orientation to our environment. Though the terms are familiar, their use by Jung differs from common definitions. Those who are considered *extraverts* (E) receive their stimulation from other people, experiences, and situations. They test their ideas through talking and doing until those ideas become clearer. They often think aloud. They are outwardly emotional and expressive. What you see is what you get with extraverts. *Introverts* (I) on the other hand rely on their own mind, heart, and soul. They mull over their thoughts and actions, reflecting until they determine they are valid. They are not ready to translate their internal thoughts for the external world. In fact, the external world may never see the real introvert (Myers, 1980).

After Jung's work was translated and made available in the United States, Katherine Briggs became very interested in psychological types. She and her daughter, Isabel Briggs Myers, explored the types with their friends and family. After considerable experience with Jung's types they became convinced that there was another dimension. This dimension reflected people's attitude taken toward the outer world. This new dimension was classified as *perceiving* (P) or *judging* (J). Perception is what people see and judgment is what they decide to do about it. It determines whether a person uses their judgment or their perception when they are interacting with the outer world. Consequently, an extravert with judgment preference would have a dominant type of thinking or feeling when dealing with the outer world. Conversely, it would seem that an introvert with perception would have a dominant type of sensing or feeling when dealing with the outer world (Myers, 1980).

Myers (1980) determined that the introvert's dominant process does not show on the JP preference since they prefer not to use their dominant process when dealing with the other world. For instance, an introvert with a perception preference would use either sensing or intuition when dealing with the outer world. If the results indicated sensing as the perception preference, that would be what they show to the outer world. In actuality, they would prefer intuition and would use it in their inner world. Those who are classified as judging want closure. They want to regulate their lives. Those who have things open-ended and want to understand life are classified as perceptive (Myers, 1980).

These types combine to make sixteen personality types as defined by Briggs and Myers. Since a person has a preference in each dimension these combine to provide a composite of the personality type by which a person is characterized. For instance, an extravert who perceives by sensing, makes judgements as to those perceptions through thinking would be classified as an ESTJ (Myers & McCaulley, 1985).

Field Dependence-Independence

Herman A. Witkin's research focused on the perception of individuals and to what extent their perception was influenced by the context in which it appeared. His original experiments involved a physical determination of the subject's relation to the surrounding environment by requiring the subject to move a chair into an upright position as determined by its relationship to a "slanted room." Subjects who could achieve a true upright position were considered field independent, while those who aligned the chair in relation to their surroundings were classified as field dependent. Today, field dependence-independence is determined through the use of the Embedded Figures Test or the Group Embedded Figures Test, paper and pencil instruments (Guild & Garger, 1985).

Witkin concluded through extensive research that "the field-dependence-independence dimension influences one's perceptual and intellectual domains as well as personality traits such as social behavior, body concept, and defenses" (Guild & Garger, 1985, p. 29). The field dependent individual is influenced by the context or reference in which they find themselves. They perceive globally, have a social orientation, see relationships, and seek externally defined goals and reinforcements. Those individuals who are field independent perceive analytically, have an impersonal orientation, rely on self-defined goals and reinforcement (Guild & Garger, 1985).

Research has shown that field independent individuals tend to select careers which require analytic skills such as engineering and science, while field dependent individuals go into careers which call for more interpersonal skills such as teaching and the social sciences. For those individuals who do choose teaching, more field independent teachers are found in mathematics and science while the social sciences have more field dependent teachers. In addition, women are more likely to be field dependent (Claxton & Murrell, 1987). Since most of the research in field-dependence/independence was done in the area of psychology the full extent of the educational implications have not been determined.

The Dunn and Dunn Model

The Dunn model of learning styles is accepted and used by many to be for several reasons. Not only is it the most widely used, but it has a well-developed instrument for identifying the learning styles of students. The large body of research using the Dunn and Dunn model has contributed information, knowledge, and insight concerning the learning styles of students and how to effectively teach to the learning styles of students.

Rita Dunn (1991, p. 5) defines learning style as "a combination of many variables which contribute to learning, each in its own way and all working together as a unit." "Learning style, then, is the way in which each learner begins to concentrate on, process, and retain new and difficult information" (Dunn, 1991, p. 5). The learning styles model designed by Dr. Rita Dunn and Dr. Kenneth Dunn (Dunn et al., 1989c) encompasses five overall stimuli each of which include several elements. They are environmental, emotional, sociological, physical, and psychological. Appendix A contains a model of the Dunn and Dunn learning styles.

Environmental Elements. The elements in environmental include: noise level, light, temperature, and design. These stimuli are considered biological, that is they are innate to the individual though they can change slowly over time. Each environmental element is also broken into two parts.

The element of noise level determines whether a student works better with or without background sound. A student who needs sound many times finds it necessary to counteract all the distractions which occur from random noise. The absence of background noise allows every other sound which occurs to distract the learner from the task at hand. Other students require a noise-free environment in which to learn difficult or new material. For them, background sound becomes a distraction (Dunn, Dunn et al., 1989c; Dunn, 1991).

At some time everyone has been advised to turn up the light if they were reading in a low-light situation. Through learning styles it has been determined that many students actually learn better in such a low light situation. In fact, it has been found that florescent lights stimulate many children to the point that they become fidgety and hyperactive in a classroom. On the other hand, many students learn better when there is bright light, either artificial or natural (Dunn, 1990, 1991).

Temperature is also on two ends of the spectrum, warm or cool. Even within a family, no two persons are comfortable in the same temperature, one will think it is either too cool or too warm. Such is the situation with students, no classroom is going to be satisfactory for all students. Obviously this is one factor in the classroom environment which is more difficult to control. A small heater in cold situations and fans in warm situations may help. School dress codes today permit leeway so students may dress more appropriately for classroom temperature comfort.

Design refers to the arrangement of the classroom and its furniture. Most classrooms have what is referred to as a formal design, (i.e., desks arranged row upon row). Classrooms which have an informal design have tables and chairs, carpeted areas and soft, relaxing chairs. These classrooms will have nooks and crannies to allow students to work in an area which is most comfortable for them (Dunn et al., 1989c; Dunn, 1991).

Emotional Elements. Within the emotional stimuli motivation, responsibility, and structure are thought to be developmental. The one exception is persistence which is considered biological.

Many students enter school with the motivation to learn. Many times teachers destroy that motivation by the manner in which they teach these eager young learners. Traditional methods in which the student is a passive learner in a formal, structured, auditory environment stifle the natural inquisitiveness of young children. By middle school the student no longer possesses the innate quest for learning (Dunn, 1991).

Responsibility and structure are the other two elements under emotional which are considered experiential. Responsibility involves a student's desire to do what they think they should do. It often correlates with conformity in a school setting. The student who does not conform to the traditional classroom is viewed as irresponsible (Dunn, 1991).

Structure correlates with the need for direction, either external direction or internal, self-direction. Students many times demonstrate their need for external direction in their inability to function in an open classroom situation (Dunn, 1991).

Persistence refers to that quality commonly known as stick-to-itiveness. Does a student continue with a task or are they easily distracted?

Sociological Elements. The third group of stimuli involve sociological elements which again are experiential and can change quickly. These involve working alone, as a pair, with peers, or in a team situation. It also determines whether a student needs an authority figure or adult while they are learning. Students who can work well under a variety of grouping situations fall into this classification of sociological elements (Dunn, 1991).

Physical Elements. Physical stimuli include perceptual strengths, intake, time and mobility. These along with the psychological elements of global/analytic, hemisphericity, and impulsive/reflective are biological.

The perceptual strengths are the ones most commonly referred to when learning styles are discussed simplistically. These are auditory, visual, kinesthetic, and tactile. The student whose perceptual strength is auditory will remember 75% of what is heard in a normal 40-50 minute lecture. Visual learners will remember 75% of what they read and see. Tactile learners remember what they write (if analytic) or draw or doodle (if global). Kinesthetic learners must be actively involved in their learning, remembering best the things they experience (Dunn, 1991).

Intake (eating, drinking, or chewing) is vital to many adolescents. Many students reflect this in their learning style. Nutritious snacks such as fruit, raw vegetables, or popcorn may be permitted for students who indicate a preference for intake. Chronobiology refers to the time of day when a student biologically experiences his or her highest energy level. It is at this time a student can best learn difficult cognitive work. The majority of middle school students function best after 10:00 a.m (Dunn, 1991).

Mobility indicates that a student needs to move frequently. This may include large muscle movements or small muscle movements such as finger tapping. Traditional classrooms are not designed to permit high mobility by the students yet this may be what is needed for optimal learning to occur for some students. Many disruptive students simply need to move around (Dunn, 1991).

Psychological Elements. Global/analytic and hemisphericity involve the concept of right brain/left brain. Globals tend to see the whole picture and then break it down into its parts. Analytics are sequential, building toward the whole. "However, what is crucial to understanding brain functioning, is that both types reason, but by different strategies" (Dunn, 1991, p. 5). No one works with just one side of the brain. The whole brain works together when one begins to think. Students who are more left-brain dominant tend to be analytic, while those who demonstrate right-preference tend to be global.

The impulsive child is the student who always calls out the answer. When they think they know what you want, they will interrupt you to give the answer. The reflective child has to repeat the question internally, evaluate the answer, and determine if there is a better answer before responding. The reflective child, then, may never have the opportunity to contribute in classroom discussion if the impulsive child dominates.

Hemisphericity. In the past 25 years, research in the area of the brain has exploded as scientists using new techniques have been able to explore areas previously restricted to speculation (Williams, 1983). Much of this research has involved the concept of hemisphericity, or the two hemispheres of the brain, right and left. Early research determined that the brain had two distinct hemispheres which controlled different functions of the body. For instance, the right hemisphere controlled the movements of the left side of the body and the left hemisphere controlled the movements of the right side of the body.

From the body of research which has developed, specific functions for each hemisphere can be delineated. The left hemisphere is considered analytic, linear, and sequential. It takes the pieces and creates the whole in a step by step progression. It is most efficient for verbal processing. The right hemisphere, on the other hand, is considered global, seeing the whole before the parts. Its most efficient functions are visual and spatial processing (Williams, 1983).

Research Base

Most learning styles research has been limited to studies involving elements from just two stimuli: environmental and physical. These elements are mobility, light, design, and time. The assumption could be made that these were selected since they were the most easily controlled.

Mobility. In 1985, Miller focused on nine students who had a pronounced need for movement as indicated by the Learning Style Inventory - Primary Version. To determine the relationship between mobility and the standardized testing environment, 21 second grade students were tested. The students were given one form of the Gates-MacGinitie Reading Test in a traditional setting with no movement allowed. The same subjects were tested with a second form of the same test at a later time. During this test a mobile environment and change of location for the students was permitted. The results showed a .05 significance using the Wilcoxon Matched-Pairs Signed-Rank Test. Six of the nine students who required mobility scored equally as well or better on the test when in a mobile testing environment. The researcher found the testing environment was a factor in the student achievement differences on the Gates-MacGinitie Reading Test (Miller, 1985).

Time. Other studies have focused on time of day as it relates to instruction. Gardiner (1986) used two types of instruction (multi-sensory and traditional instruction using lecture and visuals) and two times (morning and afternoon) for social studies instruction with low achieving fourth grade students in an urban setting. All students were presented one week instructional units which included a pre-test, an intermediate test, and a post-test. Higher mean achievement scores on the intermediate and post tests were evidenced in both the morning and afternoon sessions when the multi-sensory instructional package method was employed. The highest mean achievement scores were recorded for the afternoon sessions indicating this would be the most advantageous time and instructional strategy for the subjects.

Tenth and eleventh grade students in a sequential math course in a suburban Long Island high school were given the Learning Styles Inventory and the time preferences of 141 were diagnosed (Smith, 1987). The final sample consisted of 15 scheduled in math according to their matched time preference and 15 scheduled in math according to their mismatched time preference. They remained in this schedule for a four day experimental period. The students were administered a pretest, posttest, attitude scale, and a test of critical thinking ability. Those students who were in time preference matches achieved at a higher level than their counterparts in a mismatched environment. The study found that average to above average students adapted to conditions incongruent with their learning style preferences as indicated by the attitude scores. Smith (1987) also found that students who preferred morning learning were significantly better critical thinkers than those who preferred afternoon learning.

A third study involving time preference on math and reading achievement test scores of third, fourth, fifth, and sixth grade students enrolled in a suburban NY district was conducted over a period of two years (Virostko, 1983). The learning style time preference of 485 students was identified. Each student's instructional schedule in math and reading was determined and checked to determine whether the 286 students who comprised the population were matched or mismatched for their time preference in each subject. Results showed that student's whose time preference and class schedule were congruent scored significantly higher on achievement tests in mathematics and reading. Lower achievement scores were evident when time preference and class schedules were dissonant.

Light. An early study involving the element of light was conducted by Krimsky in 1982. The Learning Style Inventory was administered to the total population of 4th grade students in three elementary schools in a suburban New York district to determine their preference for light. The students were randomly selected and equally assigned to two groups, regardless of their preference. One group was tested in a brightly illuminated environment and the second group was tested in a dimly illuminated environment. The results revealed that students who were tested in an environment that matched their light preference scored significantly higher in reading speed and reading accuracy.

Design. The effect of design on students' standardized test scores was determined in a study by Stiles (1985). The Learning Styles Inventory was administered to 163 fifth grade students. Each student was then assigned to one of three categories determined by their tested preference for formal design, informal design, or no preference. They were then randomly assigned to three equal groups of 39 students which were composed of 13 students of each preference. The first group was tested in a formal environment and the second group was tested in an informal environment. The California Achievement Test (1977 edition), Mathematics Concepts and Applications, and the Reading Comprehension Subtests was given to each group. The results from the study indicated that standardized test scores in math concepts and applications and reading comprehension are not affected by a preference or lack of preference for formal or informal design.

An earlier study (Hodges, 1984) found different results when students were matched and mismatched with their design preference. Thirty-two 7th and 8th graders in remedial math in a New York City alternative junior high school were tested for their individual design preference using the Learning Styles Inventory. Achievement on a criterion-referenced test of metric conversion was then compared with attitudes when students were matched or mismatched according to their design preference. Hodges (1984) found that when students were matched with complementary instructional settings they achieved significantly higher mean test scores and demonstrated statistically more positive attitudes. She concluded it was important to determine the learning styles of remedial students and provide complementary classroom designs for these students.

Mathematical Achievement. In 1985, Calvano compared the learning styles of high and low mathematics achievement students to determine if significant differences existed between achievement levels for each of the 22 subscales of the LSI. In addition to the mathematical achievement categories, she looked at gender and grade level to determine if significant differences existed in learning styles which could be attributed to these categories. Her final aim was to determine if developmental changes in learning style occur across grade levels.

Mathematics achievement level was determined from the SRA Achievement Series and learning style preferences from the LSI for 290 students in grades 6 through 8. This data was analyzed using a one-way analysis of variance with an alpha level of .05.

She found that students with high mathematical achievement show a stronger learning style preference for responsibility, persistence, intake, and warmth while students with low mathematical show a learning style preference for tactile learning experiences, teacher motivation, the presence of authority figures, and mobility (Calvano, 1985).

Summary

Learning styles have achieved prominence in instructional strategies within the last decade. Though several models have evolved, the Dunn and Dunn model is the most widely used in the classroom. This model attributes the aspects of learning style to five stimuli (environmental, emotional, sociological, physical, and psychological) which comprise 22 elements. Student learning styles are identified by a Learning Style Inventory comprised of 104 items which indicate student preference. Research using the Dunn and Dunn model has shown that modifying the learning environment to adjust for the learning styles of students can affect achievement, classroom behavior, and test scores.

Evaluation of Mathematics Achievement

Evaluation has evolved from solely a method to assess the progress of students to the current interest in "providing information to support policy and program decision making" (Romberg, 1992, p. 10). This is particularly prevalent in programs such as Chapter 1 and advanced placement. This section will focus on the evolution of assessment in mathematics education.

Standardized Tests

Mathematics achievement is commonly assessed through the use of a standardized test, "an objective measure of a behavior sample, obtained under uniform conditions (Anastasi, 1971, p. 391). Though there is a distinction between the applications of tests in terms of diagnosis and prediction it is not a basic distinction. "Diagnosis refers to present condition whereas prediction connotes a temporal estimate" (Anastasi, 1971, p. 392), for example, the ability to succeed in college from a college entrance examination. The distinction becomes blurred when one considers that the diagnosis of low mathematical achievement implies a prediction of what the student will do in future mathematics courses. But in actuality, at best "[n]o test can do more than measure present behavior. Only in the sense that present behavior serves as an indicator of other, future behavior can a test measure capacity" (Anastasi, 1971, p. 394).

Contemporary forms of standardized tests have evolved from rather crude assessments that sought to evaluate a student's knowledge of a particular subject area by short answer responses. Today, the application of technology to testing has resulted in multiple choice tests that can be scored through the use of electronic scanners and provide relatively prompt feedback of results. These tests developed from a compromise between comprehensive essay-type examinations and the need to provide timely feedback to students and school personnel (Barrow & Milburn, 1986).

Another factor that distinguishes these tests and gives them their title is standardization that includes uniform procedures and norms. The objective nature of standardized tests applies to the administration, scoring, interpretation of results and the evaluation of the test itself. Every aspect of the construction, application, and interpretation of a standardized test is designed to minimize subjectivity. "Standardization extends to the materials employed, time limits, oral instructions to examiner, preliminary demonstrations, ways of handling questions from examinees, and all other details of the testing situation" (Anastasi, 1971, p. 392).

Standardized tests provide quantitative data about a group rather than the individual since individual results cannot be interpreted with norms, a measure of average performance. Individual results are evaluated by comparing it with other scores obtained on the same instrument. Since norms evaluate the relative frequency of different amounts of deviation above and below the average performance it is possible to "evaluate different degrees of superiority or inferiority" (Anastasi, 1971, p. 393).

Reliability, the consistency of results obtained by the same person when tested on separate occasions with the same form, and validity, whether the tests actually measures what it purports to measure, are also factors which distinguish standardized tests. The reliability and validity of these tests is important in determining of whether the specific test meets the requirements for which it is being used. Stringent measures are used in determining these factors and maintaining acceptable levels (Barrow & Milburn, 1986).

Results from standardized tests are used for many purposes which include placement of students in special programs, allocation of resources, effectiveness of programs, and comparison of teachers, schools, and districts (Stenmark, 1991).

Alternative Assessment

In 1989, the National Council of Teachers of Mathematics issued their Curriculum and Evaluation Standards which de-emphasized computational skills and placed increased emphasis on process and content (NCTM, 1989). This shift necessitated a change in assessment procedures from those which stressed computational proficiency to methods which would evaluate strategies, processes, higher order thinking skills, communication, and attitudes. To deal with this shift, procedures such as performance assessment, portfolios, observation, and interviews are recommended (NCTM, 1989). Calculators, manipulatives, and measurement devices are provided for use during assessment. Students are encouraged to demonstrate the process which they use in solving mathematical problems.

Though many states and districts are using alternative assessment to evaluate mathematical achievement, a satisfactory resolution has not been achieved. The subjective aspect of assessment other than objective questions necessitates a scoring rubric. Examiners must be trained. Scoring is time-consuming, labor intensive, and expensive. The types of statistical analysis which was used in comparing objective tests cannot be employed for subjective assessment (Rothman, 1992).

Standardized tests have not kept pace with alternative assessment. Consequently, most standardized assessment still relies on multiple choice, timed tests in computation, concepts, and problem solving to determine mathematics achievement. But the shift is toward open-ended problems, calculator usage, and non-traditional problems which require an understanding of several concepts.

Summary

The Chapter 1 program has been in existence almost 30 years. During that time it has provided supplemental mathematics instruction to educationally deprived students. This instruction has been, for the most part, traditional with an emphasis on basic skills and remediation. Many children, once identified as Chapter 1, never catch up with their peers. Learning theory indicates that not all children learn at the same rate. Students understand and retain knowledge which they have constructed. Research also shows that these children may be more successful and achieve at a higher level if they are taught to their learning styles. Alternative assessment techniques may also provide a more accurate picture of their actual ability and achievement.

CHAPTER III

METHODS AND PRESENTATION OF THE DATA

The methods and procedures used in conducting this study are described in detail in this chapter. A description of the research approval process, population and sample, and the instruments, the Iowa Test of Basic Skills and the Learning Style Inventory, begin the chapter. Data collection methods, and statistical procedures used in evaluating the data follow. Descriptive statistics of the population and sample and interview and observation data conclude the chapter.

Research Approval

Federal regulations and Oklahoma State University policy require review and approval of all research studies that involve human subjects. The Oklahoma State University Research Services and the Institutional Review Board conduct this review to protect the rights and welfare of human subjects involved in biomedical and behavioral research. In compliance with the aforementioned policy, this study received the proper surveillance, was granted permission to continue, and was assigned the following number: ED-93-097. Appendix B contains the approval form.

It is the policy of the school district in which this study was conducted for any research to be approved by the district Research Review Committee. Request for permission to conduct research in the district was submitted to the committee prior to commencing the study. After review by the committee, permission was granted for the study.

Population and Sample

As noted in Chapter 1, the population for this study was students enrolled in an urban middle school in a large metropolitan area in a southwestern state. This middle school is one of over 10 in a district of approximately 42,000 students. Though its student population is drawn from an attendance area that is a cross-section of the socioeconomic strata, over 50% of the students qualify for free or reduced lunch. In the fall of 1992, the enrollment in this school was about 740 students.

Student participants were selected for this study using two criteria. The first criteria was a total mathematics achievement score on the Iowa Test of Basic Skills. The second criteria was a completed learning styles inventory with a consistency score of 70 or above. In addition, only those students who did not need special services in mathematics were included in the study. Special services included learning disabled, mentally retarded, mentally trainable, and multi-handicapped. All students who met both criteria and were not identified as needing special services were included in the study sample.

Results from 678 student records were available to the researcher. Of these, 542 records had a consistency score of 70 or greater. Because it was necessary to identify the name of each record to enter the total mathematics NCE score from the Iowa Test of Basic Skills, ethnicity, gender, and grade, seven of these LSI inventories were eliminated because they did not have a name which could not be identified. Of these students, the total mathematics scores from the Iowa Test of Basic Skills were available for 402 students. Following removal of the scores of students who were identified as receiving services in special education for mathematics 382 records remained. This comprised the study sample.

Sample Demographics

The records of the 382 students contained information concerning the grade, gender, ethnicity, total mathematics score from the ITBS, and the preferences on five subscales of the LSI. The data were disaggregated by grade level, gender, and ethnicity to determine the relationship to the school population and for purposes of statistical analysis.

Grade Level Distribution. Almost 75% of the students were in the 6th and 7th grades. This is not inconsistent with the distribution of enrollment in the three grades levels at this middle school. The eighth grade class normally has fewer students than does either the sixth or seventh grade. The number and percentage of students in each grade level is given in Table 1 on the following page.

TABLE 1

NUMBER AND PERCENTAGE OF SAMPLE
IN EACH GRADE LEVEL

Grade	Number	Percentage
6	138	36.13%
7	138	36.13%
8	106	27.74%
Composite	382	100.00%

Gender. Females comprised 57.85% of the total sample for this study. This disparity is not evident in the total student population of the school where there were 369 males and 371 females, almost an equal split. No explanation can be given for this deviation from the total population. Table 2, on page 60, details the sample distribution by gender and grade level.

TABLE 2

IDENTIFICATION OF SAMPLE BY GENDER AND GRADE LEVEL

Grade	Males	Percentage	Females	Percentage
6	66	47.83	72	52.17
7	58	42.02	80	57.98
8	37	34.90	69	65.10
Composite	161		221	

Ethnicity. Students' ethnicity was determined from information provided for school records by the parent when the student was first enrolled in the district. The students in this study represented five categories of ethnic background: white, black, hispanic, American Indian, and Asian. The actual ethnic distribution in the total school population was white - 61%, black - 21%, hispanic and Asian - 4%, and American Indian - 14%. The composite number of minority students in the study was 135 or 35.34%. The number of students in each category and the percentage of the total records is presented in Table 3 on page 61.

TABLE 3

ETHNIC DISTRIBUTION OF STUDENTS BY
GRADE LEVEL AND ETHNICITY

Category	Grade 6	Grade 7	Grade 8	Composite	Percentage
white	85	84	78	247	64.66
black	15	26	17	58	15.18
Hispanic	8	4	1	13	3.41
Amer. Indian	25	23	10	58	15.18
Asian	5	1	0	6	1.57

Instrumentation

The following section will describe the two instruments from which the quantitative and qualitative data were obtained. Mathematical achievement was determined from the Iowa Test of Basic Skills, the standardized test given in the district. Data for the student learning styles were obtained from the self-reporting Learning Styles Inventory. Development of the interview protocol concludes this section.

The Iowa Test of Basic Skills

The Iowa Test of Basic Skills is a norm referenced standardized test which "measures the development of general cognitive skills in ... Mathematics" (Lane, 1992, p. 421) and is used to monitor student achievement or for instructional improvement. The first edition was developed almost six decades ago as the Iowa Every Pupil Test of Basic Skills (Linn, 1989). There are presently three alternative forms, G, H, and J, with three batteries: Early Primary (Levels 5 and 6), Primary (Levels 7 and 8), and Multilevel (Levels 9 through 14). The forms have norms for 1984-1985 or for 1988 (Lane, 1992).

The content specifications are based on several sources, among them analysis of textbooks and instructional materials, literature review, opinions of curriculum specialists and reviews by "professionals from diverse cultural groups for fairness and appropriateness of content for pupils of different backgrounds: geographic, urban/rural, sex, race, etc." (Linn, 1989, p. 393). In addition, they are influenced by feedback from users and "value judgments regarding the importance of the material. Test items are shaped by studies of student errors, item analyses, and studies of differential item performance by gender and racial-ethnic group" (Linn, 1989, p. 393).

The difference in the development of the 1988 norms from the 1984-1985 standardization was significant.

> In 1985, Forms G and H were administered to students from a nationally representative sample of schools and districts. Appropriate sampling weights were used in generating percentile data to ensure that the standardization

> sample was adequately representative with respect to geographic region, public/nonpublic schools, and the socioeconomic status. In 1988, the process of standardization was different in that it consisted of only ITBS customers; it did not require any new testing (Lane, 1992, p. 424).

This change from the earlier standardization process was apparently necessitated by the high cost of national standardizations and "the call for annual or biannual norms for achievement test batteries based, in part, on Cannell's (1988) controversial commentary on how all 50 states are testing above the national average" (Lane, 1992, p. 424).

Interpretation of achievement tests is in part content-based. "A strictly content-based interpretation is an interpretation of a score made directly in terms of the particular domain of tasks on the test without reference beyond those tasks to other constructs or other implications of the scores" (Riverside, 1986, p. 29). For example, a student's score on the mathematical computation achievement test would indicate the student's ability with the arithmetic operations of addition, subtraction, multiplication, and division. It would not indicate the student's ability at problem solving or her understanding of mathematical concepts.

The reliability coefficients for equivalent forms of the test range from .70-.90. Internal consistency reliability (K-R20) coefficients are above .85 (Lane, 1992).

The Learning Styles Instrument

In 1967, Drs. Kenneth and Rita Dunn (Dunn et al., 1989b) developed an instrument which they believed "accurately identified the range of varied personal characteristics that affected how individuals learned in the classroom prior to the

1970's" (Dunn et al., 1989c, p.26). Dr. Gary Price, a colleague of the Dunns at St. John's University became interested in the instrument in 1974. Through statistical analysis he isolated the items from the questionnaire which achieved the greatest consistency and from these analyses the Learning Styles Inventory (LSI) was developed. Since 1975, the LSI has been tested and revised several times. The latest version was revised in 1989 and was the version administered to the students in this study (Dunn et al., 1989b).

The LSI (grades 5 - 12) is a self-reporting, Likert scale, instrument which consists of 104 questions in 22 areas designed to determine the learning style of those to whom it is administered. Questions are phrased both negatively and positively (selected LSI questions are included in Appendix A). Scoring is typically done by computer with a print-out profiling the learning style preferences of the subject. The profile indicates the student's preference as a standard score, with a mean of 50 and a standard deviation of 10 (Dunn et al., 1989c). Scores from 20 through 40 indicate a low preference for that element; scores from 60 to 80 indicate a high preference for that element; and the middle scores from 40 to 60 indicate no preference for the element. For example, a score of 70 on the element of sound would indicate the student learns better when sound is present. A score of 30 would indicate the student needed quiet when learning new and difficult material. A score between 40 and 60 would indicate sound was not a important factor in the learning style of this student. Scores in the lower or upper preference area are critical because these scores indicate student preferences that affect learning new and difficult material (Dunn, et al., 1989c).

The LSI encompasses four of the five areas contained in learning styles as defined by Dunn and Dunn (1989c): *environmental* which includes sound, temperature, light, and design; *emotional* which includes motivation, responsibility, persistence, and structure; *sociological* which includes learning alone, with peers, with adults, or in several ways; and *physical* which includes the perceptual preferences of auditory, visual, tactile, and kinesthetic, time of day, intake, and mobility. The last two subareas on the LSI are parent figure motivated and teacher motivated. The *psychological* area includes the elements of hemisphericity and impulsive/reflective which are not addressed by the LSI. A combination of the subscales of sound, light, design, persistence, and intake can indicate a student's processing style as either global or analytic, the third element in this area. Though the questions on the LSI give some indication as to what preference is being assessed, the inventory is not broken down into specific reference areas or subareas (Dunn, et al., 1989b).

The LSI incorporates a consistency score based on responses to questions repeated (item pairs) throughout the inventory. If a student responded to repeated questions in a like manner then it is reflected in the consistency score. A consistency score of 70 indicates that "...responses to 70 percent of the item pairs were in agreement...The higher the consistency score, the greater the confidence that can be placed in interpreting the student's responses" (Dunn et al., 1989c, p. 12).

"Research in 1988 indicated that 95 percent (21 out of 22) of the reliabilities are equal to or greater than .60 for the Likert scale English translation in grades 5 through 12." (Dunn et al., 1989c, p. 30) The reliabilities ranged from a low of .55 on the chronobiology preference of late morning to a high of .88 on the preference of working alone or with peers. Eighteen of the 22 areas have a reliability of .72 or higher.

Only five subscales of the Learning Style Inventory were used in this study. Those subscales were noise level, light, design, intake, and mobility. The subscales were selected for two reasons. Each element had a reliability coefficient above .75 as determined by Hoyt's Reliability (equivalent to a KR-20) (Dunn, et al., 1989c). In addition, each of the elements selected could be easily adjusted by the teacher in a classroom setting. For instance, light can be dimmed in one section of a room for students who have a preference for dim light while learning new and difficult material. The reliabilities for the specific subscales which were used in this study are as follows: sound - .83, light - .78, design - .78, intake - .85, mobility - .85 (Dunn, et al., 1989c).

Interview Protocol

Given the focus of this study, students needed to be asked about their perception of their learning styles and how they accommodated their learning styles. A set of general, open-ended questions was developed to explore students' understandings about learning style preferences generally and specifically their own learning styles preferences in their mathematics classroom. The initial protocol was piloted on a sample of students to determine whether or not it was appropriate for illiciting the information needed. Analysis of student responses indicated only slight modifications in the questions. The final version of the protocol is included in Appendix C.

The Researcher

Since this study includes a qualitative component it is important to establish the expertise and reveal the bias of the researcher. This permits the reader to understand the lens through which I viewed the study. The following section describes my experience and qualifications.

I am a public school educator with 25 years experience in the classroom, the last seven in my district's Chapter 1 mathematics program. Upon my request to shift to mathematics from physical education, my assignment was to teach Chapter 1. Chapter 1 is often a dumping ground for not only students, but teachers. Many administrators assign ineffective teachers to the Chapter 1 program so they will come in contact with fewer children due to the mandated smaller class size. Consequently, Chapter 1 is often viewed as a inferior assignment. To me it was an ideal situation. My background in a kinesthetic area contributed to my teaching style which allowed movement within the classroom, and encouraged the use of manipulatives and hands on activities. I rapidly became involved in professional activities in mathematics in an effort to learn as much as I could about teaching my students. Within two years after attending national conferences in mathematics education I was presenting workshops and seminars on mathematics education for Chapter 1 students. Through the encouragement of colleagues in mathematics education at the university level I began my doctorate and became interested in learning styles. My approach to working with my Chapter 1 students, which emphasizes enrichment rather than remediation, was recognized when I was selected as the 1992 Oklahoma recipient of the Presidential Award for Excellence in Teaching Mathematics. My interest in helping students in Chapter 1 mathematics to succeed led me to learning styles.

Procedures

The following section will describe the test administrations, scoring, quantitative data management, and interview schedules.

Test Administration

The Iowa Test of Basic Skills was administered by school personnel in the spring of 1992 to all students in the middle school as part of the district evaluation program. The state requires all fifth and seventh grade students to be administered a state evaluation. Students identified as sixth and eighth graders in this study were in the fifth and seventh grades when the test was administered. Consequently, they were administered Form J while students identified as seventh graders were administered Form G (1984-1985 norms). The total mathematics score for each student was available to the researcher as a rank order list. Only data from the 1992 Iowa Test of Basic Skills were used to determine mathematical achievement.

In the fall of 1992, as part of a school improvement project, each student in the middle school was given the Dunn and Dunn Learning Styles Inventory (LSI) by language arts teachers during class time. Prior to administering the LSI the students were shown the video "The Look of Learning Styles" to acquaint them with learning styles. The inventories were not given to students in three special education classes with severely handicapped students. In addition students who were absent were not given a make-up day to complete the inventory.

Scoring

Riverside, the test publisher, was responsible for scoring the ITBS and the results were made available to the school in both rank and alphabetical order.

The LSI inventories were computer scored through the office of the county superintendent. The results from each inventory were printed on a profile which indicated the student's preference in each of the 22 subscales. All the information from the LSI profile on each student was entered into the computer database program Q&A (Wilkinson, 1991).

Quantitative Data Management

Eleven variables were used for the study. These included name, grade level, NCE score on the total mathematics section of the ITBS, consistency score on the

LSI, ethnicity, gender, and subscale preference scores from the LSI for the elements of noise level, light, design, intake, and mobility.

To determine mathematical achievement the total mathematics score from the Iowa Test of Basic Skills was used. The ethnicity of each student was determined from the permanent record maintained by the district. When a student first enrolls in the district the parent or guardian indicates the ethnicity of the student. Five categories emerged in the records: white, black, hispanic, American Indian, and Asian.

These 11 variables were segregated into a separate database which was exported to a DIF database file. This DIF file was imported into the statistical program SYSTAT (Wilkinson, 1990).

Qualitative Data Management

The qualitative segment of the study involved interviewing selected students concerning their learning styles. Students were selected by the researcher after looking at the learning styles inventories. Students whose inventory results indicated a preference for noise level, low light, informal design, high mobility, and intake were contacted for interviews. These students included both high mathematical achievement and low mathematical achievement as determined by the total mathematics score on the Iowa Test of Basic Skills.

Identified students were contacted by the researcher and asked if they would like to participate in an interview about their learning styles. An information form with attached consent form was then given to the students to take home to their parents. Those students who returned the signed consent form (a copy is included as Appendix C) were interviewed using the developed protocol. I interviewed a total of five students.

The interviews were audio taped and transcribed. Hard copies of the interviews were then reviewed and collapsed into data categories prior to analysis.

Several of the students who were interviewed had been enrolled in my Chapter 1 mathematics class. Observation was an additional factor to assess the consistency between the students' learning style profile and their choices in the classroom.

Descriptive Statistics

The following sections will present the descriptive statistics which were found in this study. It will include the percentage of students in each category of mathematical achievement, the percentage of students who indicated preferences for the selected subscales of the LSI, and the combined mathematical achievement level and LSI subscales preferences by grade level and achievement. Additional comprehensive descriptive statistics are located in Appendix D.

Mathematical Achievement

The mathematical achievement of the students was determined by results from the total mathematics NCE score on the ITBS which was administered to all students in the middle school during the spring of 1992. The total mathematics score consists of a score from each of three subsections from the ITBS: concepts, problem solving, and computation. Although a determination of low, average, and high achievement was reached from percentile rank, the actual score used for statistical purposes was the NCE equivalent conversion for each of these percentile ranks. Using the NCE score allows one to aggregate the data. A NCE equivalent conversion for the percentile rank of 35 is a NCE score of 42, while the NCE equivalent conversion for the percentile rank of 65 is a NCE score of 58.

Students with a NCE score of 42 or less were identified as low achieving or Chapter 1. Students with a NCE score greater than 42 but less than 58 were identified as average while students whose NCE score was 58 or greater were identified as high achieving.

The students who were identified as Chapter 1 might not have been enrolled in Chapter 1 during the school year because students may be withdrawn from the program by parent request. In addition, because of a class size limitation of ten students, not every student who is eligible for Chapter 1 may be served. No attempt was made in this study to determine if all students who were identified as within the Chapter 1 eligible category were actually enrolled in Chapter 1 mathematics during the 1992-1993 school year.

The number of students in each achievement category by grade level and percentage of the total records are presented in Table 4 on page 72. Chapter 1 students had an NCE score of 42 or below, average achieving, an NCE score between 42 and 58, and high achieving students had a NCE score of 58 or better.

TABLE 4

IDENTIFICATION OF MATHEMATICAL ACHIEVEMENT
OF STUDENTS

Category	Grade 6	Grade 7	Grade 8	Composite	Percentage
Chapter 1	53	46	49	148	38.74%
average	46	58	36	140	36.65%
high	39	34	21	94	24.61%

Table 5 presents the data for the mathematical achievement and the five selected subscales of the LSI of students in sixth, seventh, and eighth grade. The minimum and maximum score for the total mathematics score on the ITBS and for each selected subscale of the LSI are given. The five subscales scores could range from 20 to 80.

In the sixth grade the highest score on the ITBS for mathematical achievement was a NCE of 88, while in seventh and eighth grade the highest was 99 and 96 respectively. Though these scores appear to be almost 10% higher in the upper two grades, with a conversion to percentile rank, all the scores are within three percentile ranks or between 96 and 99.

Table 6, on page 74, presents the number of students by mathematical achievement in a preference summary for each of the five selected subscales.

TABLE 5

DESCRIPTIVE STATISTICS FOR STUDENTS' PREFERENCES
ON SELECTED SUBSCALES OF THE LSI
BY GRADE LEVEL

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum						
Grade 6	2	29	26	30	23	20
Grade 7	12	29	26	33	27	22
Grade 8	13	27	26	33	29	22
Maximum						
Grade 6	88	72	69	70	66	65
Grade 7	99	70	63	76	66	65
Grade 8	96	72	71	73	66	65
Mean						
Grade 6	47.70	48.65	41.32	44.66	51.83	53.29
Grade 7	49.37	48.32	43.28	45.89	53.71	52.37
Grade 8	45.16	50.39	43.27	45.53	52.90	51.93
Standard Deviation						
Grade 6	18.82	10.77	8.10	9.26	11.45	10.95
Grade 7	16.70	11.10	8.30	10.5	8.90	11.4
Grade 8	14.72	10.65	9.06	8.96	9.28	11.86

TABLE 6

DESCRIPTIVE STATISTICS FOR STUDENTS' PREFERENCES ON SELECTED SUBSCALES OF THE LSI BY MATHEMATICAL ACHIEVEMENT

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum						
Chapter 1	2	27	29	33	23	20
average	43	29	26	30	25	22
high	58	29	26	33	25	25
Maximum						
Chapter 1	42	72	69	73	66	65
average	57	72	63	67	66	65
high	99	72	71	76	66	65
Mean						
Chapter 1	31.50	48.99	42.38	45.83	52.62	52.86
average	49.51	48.28	42.36	45.15	53.34	52.37
high	70.11	49.67	43.17	44.85	52.30	52.45
Standard Deviation						
Chapter 1	8.82	10.07	8.89	9.25	10.42	10.76
average	4.15	11.40	7.66	9.59	9.28	11.68
high	10.61	11.40	9.06	10.38	10.43	11.92

Student Preferences on the LSI

The descriptive statistics concerning the five subscales of the LSI were the most informative as to the preferences of the students in each of the three levels of mathematical ability.

There were 148 student records which fell within the category of Chapter 1 eligible. Using these records, the number of students who had a preference in each of the five subscales used in this study were determined. As indicated by the information in Table 7, the students in this study did not demonstrate an overwhelming choice for the preferences within each subscales which were reported in the literature for underachieving students (O'Neil, 1990; Dunn, 1991, Center, 1992). Only on the subscale of light (prefer dim light) was the preference over fifty percent.

TABLE 7

NUMBER AND PERCENTAGE OF SAMPLE
INDICATING SELECTED PREFERENCES
ON FIVE SUBSCALES OF THE LSI

LSI Subscale	Observations	Percentage
Prefers sound	28	21.21%
Prefers dim light	77	58.00%
Prefers informal design	47	35.60%
Prefers intake	47	35.60%
Prefers mobility	54	40.90%

Discussion

The following discussion of student preference by number of cases and percentage within each subscale, as presented in Table 8, compares the demographics of this study to the literature.

TABLE 8

STUDENT PREFERENCES BY NUMBER AND PERCENTAGE
ON SELECTED SUBSCALES OF THE LSI

	Chapter 1		average achieving		high achieving		composite
noise level							
prefers quiet	42	(28.4%)	46	(32.8%)	26	(27.7%)	114
no preference	**78**	**(52.7%)**	**68**	**(48.6%)**	**47**	**(50.0%)**	**193**
prefers sound	28	(18.9%)	26	(18.6%)	21	(22.3%)	75
light							
prefers dim	**77**	**(52.0%)**	**73**	**(52.1%)**	**47**	**(50.0%)**	**197**
no preference	63	(42.6%)	63	(45.0%)	39	(41.5%)	165
prefers bright	8	(5.4%)	4	(2.9%)	8	(8.5%)	20
design							
prefers informal	47	(31.7%)	52	(37.1%)	39	(41.5%)	138
no preference	**88**	**(59.5%)**	**75**	**(53.6%)**	**42**	**(44.7%)**	**205**
prefers formal	13	(8.8%)	13	(9.3%)	13	(13.8%)	39
intake							
does not prefer	22	(14.9%)	18	(12.9%)	15	(16.0%)	55
no preference	**79**	**(53.4%)**	**82**	**(58.6%)**	**50**	**(53.2%)**	**211**
prefers	47	(31.7%)	40	(28.5%)	29	(30.8%)	116
mobility							
does not prefer	21	(14.2)	23	(16.4%)	17	(18.1%)	61
no preference	**73**	**(49.3%)**	**67**	**(47.9%)**	**43**	**(45.7%)**	**183**
prefers	54	(36.5%)	50	(35.7%)	34	(36.2)	138

Noise Level. Fifty percent of the students who completed the LSI did not indicate a preference for sound while learning new or difficult material. The remaining students were split almost 3 - 2 with 29.8% who expressed a preference for quiet and 19.6% preferred sound. When these were divided as to mathematical ability the same pattern emerged in low achieving students. There was only a difference of 5% between the number who preferred quiet and those who preferred sound in the high achieving students. Overall, about 80% of the students expressed a preference for quiet or had no preference.

Calvano (1985), in a similar study of the mathematical achievement of middle school students, found a statistical significance in a preference for sound for high and low mathematics achievement students, with high achieving students preferring sound. Though the students in this study did not demonstate the same preference for sound expressed by high achieving students, the high achieving students did have a higher percentage of students preferring sound (22.3%) than the other two categories, an unexpected and unanticipated demographic outcome.

Light. An overwhelming preference for dim light, both as a composite group and as differentiated by achievement, was indicated on this subscale. Though a substantial number of students expressed no preference, only about 5% of the population expressed a preference for bright light.

These demographics were consistent with the profile of low achieving students (Dunn, 1991), but the number of students at the high achieving level who did not prefer light was much lower than expected.

Design. The majority of the students expressed no preference for either a formal or informal design in the classroom. The number who indicated a preference for formal design was just over 10% while the remaining students (from 31% to 41%) expressed a preference for informal design. The high achieving students had the highest percentage (13.8%) expressing a preference for formal design.

Although more low achieving students expressed a preference for informal design than for formal design, almost 69% indicated no preference. Further, the percentage of low achieving students who preferred informal design was the lowest percentage for that preference of the three groups.

These demographics are not consistent with the literature which profiled low achieving students as expressing a preference for informal design (Dunn, 1991; Center, 1992).

Intake. The vast majority of students (55.2%) expressed no preference for intake, such as chewing gum or drinking during learning. This was balanced by about 30% of the students who did indicate a preference for intake. This same relationship was maintained when each achievement level was considered individually. In each category about twice as many students indicated a preference for intake than indicated they did not prefer intake while learning new or difficult material.

Dunn (1990) asserts that slow learners or underachievers need intake while studying. In this sample, the percentage of Chapter 1 students (31.7) who preferred intake was not substantially higher than the percentage for students in either of the other levels.

Mobility. The largest percentage of students had no preference for mobility, freedom to move about. This was countered with just over 36% who preferred mobility, more than double the percentage who did not prefer mobility. Though the low achieving students had the lowest percentage of students who did not prefer mobility, they also had the highest percentage of students who expressed no preference. The high achieving student had the highest percentage of students who did not prefer mobility. All levels were within one percentage point of each other in preferring mobility.

Mobility is an area indicated in the literature as a need for low achieving students (Dunn, 1991, Center, 1992). Although a significant percentage (36.5) of low achieving students expressed a preference for mobility, a higher percentage (49.3) expressed no preference.

Qualitative Data

Four white females and one white male were interviewed in this study. One student had a consistency score of 88 on the LSI, the remaining scores were 100. Three of the girls qualified for Chapter 1 assignments, but only two were enrolled during the academic year; the remaining students were in regular mathematics classes during the academic year. To preserve the confidentiality of student information each one will be referred to with a name beginning with the letter A.

Amanda

Amanda is a very shy, reserved eighth grade student who makes excellent grades, including math. Her mathematical achievement score is 36 which makes her Chapter 1 eligible. She was not enrolled in Chapter 1 this year but was on the waiting list. Her learning style profile had only two of the five subscales in which she indicated a preference. She prefers quiet and does not prefer intake. She had no preference for light, design, or mobility.

In telling me about her learning styles she indicated her learning style was auditory, she liked bright lights, and sitting at her desk, none of which she indicated as a preference on her LSI. In responding to what helps her learn math--she responded "Just--just seeing how it's done and seeing it written." She also indicated the way in which the math teacher helped her was "She explains it on the board. She writes it on the board and goes over it with us". Her calculator helped her do her best in math.

Angel

Angel is a vibrant and social eighth grader, who experienced a great deal of academic difficulty this year. Her grades were very poor the last quarter. She has very supportive parents who expect her to do well and were very disappointed when she did not. Angel has a NCE of 45 in mathematics achievement. She was enrolled a regular math class.

Her self-reported learning style profile indicated no preference for sound, with a preference for dim light, informal design, intake, and mobility.

When describing her learning style she stated "I like to work with a friend, I have to have my music up, dim lights are the best..." She indicated a dependence on visual modality when studying, reading over material, looking at vocabulary words, reading them over and writing them down. Her profile indicated she did not prefer visual. When explaining how she works in math class she talked about lying on the couch in the classroom.

<u>April</u>

April is an energetic sixth grader who was enrolled in Chapter 1 mathematics with a NCE of 16. She has a very positive attitude toward school and works hard in class. Her LSI profile indicated a preference for dim light, informal design, and intake. Though she indicated no preference for sound, her raw score was 58, only two points from a preference for sound while learning difficult material.

She was quite descriptive when asked about her learning styles.

> I like to lie on a couch or beanbag, or have kind of an open space, like a desk. You know how it's real small? Well, like you have tables, it gives me a lot more room. Like, you know how it asks if you like bright or glare, you know, dim light: Well, most of the time I like it, you know, kind of--where it's not bright but it's not too dim. Kind of dim but not too much. Sometimes I like to snack when I'm eating [sic]. Most of the time when I get home I listen to the radio...

April's regular (she was enrolled concurrently in math and Chapter 1 math) math teacher does not facilitate learning styles in the classroom. This made a difference to April as she explained

> Well, I think it does cause on some of the tests, you know, how you get real sweaty palms and stuff, well, if you like to try to move around too much, trying to get comfortable, you know, he'll make you be quiet because you'll be disturbing the other students.

She classified manipulatives as visual materials which helped her in math. Difficult explanations gave her the most difficulty in math.

<u>Anne</u>

Anne is a quiet eighth grade student who has qualified for Chapter 1 throughout her middle school years. She is very persistent and works hard for her success. Her LSI profile indicated she preferred quiet but did not prefer mobility. No preference was indicated for light, design, or intake.

She likes "to work in a room that has lots of light 'cause I can't study when its dark. I like it when its cold and I like to chew gum or eat something, and listen to music." She went on to explain that she liked to work alone "because other people, they bother me with their talking and laughing and stuff. I can work by myself better." Her next response indicated she did not like any sounds when she was studying. When the teacher explained new or difficult material to her she wanted to see examples on the board in addition to hearing the explanation.

Allan

Allan is a self-described, bright sixth grade student who considers himself both a "quick and slow learner" depending on what he is studying. He enjoys math and finds it fun, exciting, and interesting. His NCE score of 67 places him in the high achievement level for mathematics and he was enrolled in the advanced mathematics class for sixth grade.

Allan's learning style profile indicated a preference for sound, dim light, and intake. He does not prefer mobility. He had no preference on the subscale for design.

In discussing his learning style he expressed an overwhelming preference for dim light and quiet. He likes to work alone, "partners screw around" and do not offer much assistance. This is disturbing to him because he likes to do well in math. When enumerating the factors that help him in math he listed a good pencil that stays sharp, clean paper, dim light, quiet, comfortable surroundings. In fact, at home he likes to study lying on a pillow on the bottom bunk bed because only some dim light comes through the trees. Mobility is not important to him.

Summary

The data from the student interviews indicated a preference (3 - 2) for dim light. Most students made reference to noise level, light, and intake without prompting. Consistently, they neglected to provide information about design and mobility. The verbal descriptions by April and Allan of their learning styles were the most consistent with their LSI profiles. They also were the most consistent within the interview and did not contradict earlier statements. The other students expressed preferences in the interviews which were not supported by their LSI profiles. The area of noise level produced the most inconsistency, between the interviews and the profiles and within the interviews. Most of the students indicated a preference of sound on the LSI and then described a study environment which was quiet.

Summary

This chapter presented a description of the data collection, instruments, descriptive statistics, and qualitative data. Generally, students in this study were unlike those reported in earlier experimental examinations; they did not demonstrate the same preferences for learning styles. In the next chapter an analysis and interpretation of the data will be presented.

CHAPTER IV

DATA ANALYSES AND INTERPRETATION

This study was a non-experimental, quantitative and qualitative design in which two instruments were used to determine mathematics achievement and learning style preference of middle school students. Relationships between the mathematical achievement of these students and their respective learning styles were examined. Using five subscales of the LSI and mathematical achievement levels correlations were calculated to determine if there was a linear relationship between selected learning style preferences and mathematical achievement. Analyses of variance were calculated to determine if there were a significant difference in the learning styles of those students who were identified as Chapter 1, average achieving, and high achieving in mathematics. The information derived from the statistical analysis was supplemented by observation and student interviews. This chapter will analyze and interpret the results.

Statistical Analysis

The learning style preferences of each student for five subscales of the LSI were correlated with mathematical achievement to determine if a linear relationship between learning style preferences and mathematical achievement scores existed. A one-way analysis of variance was also run to determine if significant differences existed between students' learning styles and mathematical achievement levels.

Correlations

The data for mathematical achievement were divided into three groups representing Chapter 1 students, average achieving students, and high achieving students. The data from learning styles preferences of the five selected subscales of noise level, light, design, intake, and mobility were separated into three groups, standard scores from 20 - 40, 41 - 59, and 60 - 80. Using the Pearson Product-Moment Correlation on SYSTAT (Wilkinson, 1991), correlations were run between each of the three levels of mathematical achievement and each of the three groups on each of the five subscales.

No strong linear relationships were evident. Table 9 presents the correlational data.

TABLE 9

CORRELATION BETWEEN MATHEMATICS ACHIEVEMENT AND SELECTED SUBSCALES OF THE LSI

	Chapter 1	average achievement	high achievement
noise level			
prefers quiet	0.029	0.101	0.116
no preference	0.011	-0.055	-0.105
prefers sound	0.077	0.001	0.123
light			
prefers dim	-0.013	0.236	-0.041
no preference	0.025	-0.388	0.102
prefers bright	-0.229	**0.487**	0.031
design			
prefers informal	0.145	0.192	0.193
no preference	0.021	0.134	-0.186
prefers formal	0.136	-0.324	**0.467**
intake			
does not prefer	0.204	-0.115	-0.235
no preference	0.122	-0.181	-0.051
prefers intake	-0.133	0.141	-0.078
mobility			
does not prefer	**0.649**	0.040	-0.151
no preference	0.090	0.170	-0.029
prefers	0.089	-0.301	-0.164

A moderate positive correlation (.649) was found between Chapter 1 and the preference for no mobility. This would indicate that Chapter 1 students had preference for passivity in the classroom or while studying. A second moderate positive correlation (.487) was found between average achieving students and a preference for bright light. The other moderately positive correlation (.467) was between high achieving students and a preference for formal design in the classroom. Four of the seven low correlations were negative. The remaining 35 correlational relationships were very low. This indicates no linear relationship within any of the subgroups between mathematical achievement and learning style preference.

Analysis of Variance

An earlier study compared learning styles and mathematical achievement, through the use of a one-way analysis of variance, and found a variety of significant differences between the low and high achieving mathematics students (Calvano, 1985). In keeping with earlier trends, this study also examined mathematical achievement and learning style through an analysis of variance.

Several configurations of the data were used for the analysis. The first analysis was completed using three groups of mathematical achievement, (Chapter 1, average achievement and high achievement) as the dependent variable with each single learning style variable, (noise level, light, design, intake, and mobility) as the independent variable. No statistically significant differences between Chapter 1 students, average achieving students, or high achieving students were found with respect to any of the five subscales of learning styles. This indicates there is no difference in learning style preferences between Chapter 1, average achieving, and high achieving mathematics students. (Comprehensive descriptive statistics are in Appendix D.)

For the second analysis the three groups of mathematical achievement (Chapter 1, average, and high) as the dependent variable were used again. This time each subscale variable was separated into two groups, scores from 20 to 40 and scores from 60 to 80 removing those scores which indicated no preference. Again, analysis of variance did not show any statistically significant difference with respect to mathematical achievement and learning style preferences. (ANOVA tables are included in Appendix E.)

On the third analysis the groups of mathematical achievement were joined to examine low-average and high-average groupings. For the first run, the achievement scores of the Chapter 1 students were combined with the average achievement scores for a low-average group. The high achievement scores became the second mathematical achievement group. These two groups were run against the split (prefers or does not prefer) learning style subscale groups. Again, no statistically significant differences between mathematical achievement and learning styles were found. The mathematical achievement groups were then recombined, with Chapter 1 as one group and the average and high achievement students combined for a second group. Again these groups were run against the split learning style subscale groups and no statistically significant differences between mathematical achievement and learning styles were found.

Summary

The results of this study indicate there is no strong linear relationship, either positive or negative, between any of the levels of mathematical achievement and the five selected subscales of the LSI. The results of the analysis of variance corroborated the results of the correlations; there is no statistically significant difference in the learning styles of Chapter 1, average achieving, and high achieving mathematics students.

Qualitative Analysis

Five students were interviewed to determine the relationship between student responses on the LSI profile, mathematical achievement, and student perceptions of their learning styles.

Amanda

Both in terms of mathematical achievement and learning styles Amanda did not perform as either instrument would indicate. Her NCE score of 36 was overshadowed by her ability to succeed in mathematics with excellent grades. Her recitation of her learning styles expressed a preference for bright lights and formal design, neither of which was indicated as preferences on her profile. Amanda's statement that she was an auditory learner was contradicted by her assertion that "seeing how it's done and seeing it written" and her calculator, all visual indicators, were what helped her learn math.

Angel

Having an NCE mathematics score above 42, Angel's achievement score makes her ineligible for Chapter 1 services in math, but her struggles with math this year indicate she could have benefitted. As compared with her LSI profile, she was quite accurate in describing her learning style with a preference for dim light, informal design, and working with peers. But there were two areas in which inconsistencies existed. She indicated she liked "to have my music up" when studying, a preference not indicated on her profile. And she made reference to several visual activities such as reading, looking at vocabulary, and examples shown by the teacher as facilitating learning. Her learning style profile indicated she did not prefer visual.

April

The most accurate assessment of personal learning style which correlated with the LSI profile was given by April. She described dim light, informal design, intake, and sound in her portrait of her learning style. Though she talked about manipulatives as visual material, they are appropriately classified as tactile and kinesthetic, a preference indicated on her profile.

Her differentiation between her Chapter 1 math class and her regular math class in terms of her success may have a direct relationship to the options she is provided. Students are encouraged to exercise their learning style preferences in the Chapter 1 classroom; choices are provided and the environment is modified to provide for differences. On the other hand, April's regular math class is very structured, formal design, quiet, and bright lights with no opportunity for working with any materials which would stimulate a kinesthetic or tactile learning style.

Anne

There were discrepancies between the LSI profile for Anne and her responses when directly questioned about her learning style. She indicated a preference for music, bright light, and intake. Her preferences indicated on the LSI were for quiet, with no preference for light, design, and intake. But after indicating she liked to listen to music, she said she did not like to work with other students because their noise bothered her. From observation it appears that for Anne the distractions provided by other students is the problem. There is a difference between noise which transpires because of student talking and laughing and background music and she can deal with one and not the other.

There was a correlation between her preference for auditory and visual modalities while learning and her response that she liked to see examples as well as hear an explanation when learning difficult material.

Allan

Allan seems to be in touch with his learning styles when he talks about them. The only major discrepancy was between his profile which indicated a preference for sound and his expressed preference for quiet. He repeated his need for quiet and for dim light several times, even describing how his favorite place to study at home is a bottom bunk bed because it is so poorly illuminated. He was also emphatic about working alone rather than with partners. Though his profile indicated he had no preference his standard score was 41, placing him "on the line" for a preference for working alone.

Summary

Inconsistency was the most evident factor from the interviews. Student descriptions of their learning styles did not coincide with preferences indicated on the LSI. Only April and Allan were relatively consistent in portraying their learning styles as compared to the preferences on their LSI profiles. In addition, inconsistencies within individual interviews indicated the students did not have an accurate concept of their learning styles and what was the most conducive for studying. The noise level subscale produced the most inconsistency, both between the interview response and the profile and within the interview.

Summary

This chapter analyzed and interpreted the quantitative and qualitative data which was obtained in the study. The correlational statistics indicated no strong linear relationships between mathematical achievement and learning styles. This was collaborated by the analysis of variance which found no statistically significant difference in the learning styles of Chapter 1, average achieving, or high achieving mathematics students. The results of the interviews indicated inconsistencies in student perceptions of their learning styles. The next chapter will provide a summary, findings, conclusions, and recommendations.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter will summarize the major aspects of this study, report the findings and conclusions, including the instructional and administrative implications and generate recommendations for further study. It will conclude with a commentary on the study.

Summary

This study sought to examine the relationships between achievement and learning styles of middle level students. To accomplish this the relationship between the mathematics achievement and learning styles of middle level students was examined using both quantitative and qualitative methods. Specifically, the data were examined to determine if there was a correlation between or statistically significant difference in the learning styles of those students whose test scores indicated a lower level of mathematical achievement, Chapter 1 students, and those whose test scores indicated a higher level of mathematical achievement.

The research objectives were to identify the learning styles and mathematical achievement of middle school students and determine if there were a correlation between the learning styles of Chapter 1 middle school mathematics students and the learning styles of other middle school students in regular and advanced programs, and to determine if there were a statistically significant difference in between the learning styles of middle school Chapter 1 students and high achieving mathematics students. The results of the quantitative measures were supplemented with student interviews and observations.

Learning styles are the way in which students best learn new and difficult material. Several learning styles models have been developed over the last two decades. These include models by McCarthy, Gregorc, Jung, Witkin, and the most widely used model, Dunn and Dunn. As a component of learning theory, learning styles focus, not only on the cognitive element, but on other elements including the affective domain. To understand the framework for learning styles, one must look at the influence of the paradigm experientialism promoted by Dewey and Piaget who advocated learning by experience.

A review of the literature indicated that the learning styles of low achieving students could be identified, and on several subscales of the Dunn and Dunn LSI their preferences would differ from those of average and high achieving students on the same subscales. These subscales included noise level, light, design, intake, and mobility. Since the preferences of the low achieving students in these areas were not accommodated in the traditional classroom, the question arose as to whether these preferences might contribute to learning problems and eventual placement in remedial programs such as Chapter 1.

The specific category of Chapter 1 mathematics students has not been a subject of any research on learning styles, though low achieving students have been considered. It was hoped research results from this unique classification, involving not only academic achievement but economic and sociological status, may contribute new information to learning style theory.

Data were collected from student records in an urban middle school in a metropolitan area in the southwest. This data included the total mathematics score from the ITBS, the consistency score and the standard score for each subscale on the LSI, gender, grade level, and ethnicity. Through descriptive and inferential statistics the data were quantified and analyzed. Student preferences were examined through classroom observation and interviews of selected students whose LSI profile indicated consistencies or inconsistencies with anticipated preferences in relation to their mathematical achievement level.

A review of the research indicated only one previous study which sought to determine the relationship between mathematical achievement and learning styles. In 1985, Calvano compared the learning styles and mathematical achievement students in grades 6 through 8. Though the Calvano study was similar in nature to this study, her population was from a middle school with an enrollment of 333 students in a district of approximately 1400 students. There is no indication if this was a rural or suburban district. This study was conducted in an urban middle school located in a school district which has an enrollment of approximately 42,000. Other differences delineated the two studies. She sought to compare the learning styles of low and high mathematical achievement students to see if there were significant differences between the two groups as to each subscale on the LSI. She also compared the two groups on all 22 subscales in addition to comparing the groups within grade levels and gender. Her findings are splintered (35 separate findings) and fail to provide any overwhelming conclusions regarding the two levels of mathematical achievement.

This study, on the other hand, sought to determine if there were a relationship between mathematical achievement and learning styles of Chapter 1, average achieving, and high achieving students. Only five subscales from the LSI were selected for statistical comparison and analysis. This study did not attempt to examine differences which might be attributable to gender or ethnicity, though both factors were considered in describing the population.

Findings and Conclusions

The following section will present the findings and concurrent conclusions for each of the five LSI subscales which were used in this study as they relate to the mathematical achievement of students. Generalized conclusions from the study will follow.

Inferential Statistics

There was no statistically significant difference between Chapter 1 mathematics students and average or high achieving students and their learning styles.

Descriptive Statistics

Correlations run found no strong linear relationships between Chapter 1, average achieving, and high achieving students and their learning styles. Three relationships of moderate strength were found. Chapter 1 students did not prefer mobility, average achieving students preferred bright light, and high achieving students preferred formal design. The literature indicates that low achieving or Chapter 1 students prefer and even require mobility while learning (Dunn, 1989; Center, 1992).

Learning Style Preferences

The five subscales of the LSI which were used were noise level, light, design, intake, and mobility. These factors were chosen for three reasons: the reliability of each subscale was .78 or greater; teachers can alter the classroom environment to provide opportunities for students who express a preference for variations on the continuum of each subscale; and preferences within these factors were associated with low-achieving students.

Noise Level. Analysis of the data indicated that though a greater percentage of students expressed a preference for quiet over sound across all achievement levels, about 50% did not have a preference. The high achieving students had the highest percentage (22.3%) of students who preferred sound while learning new and difficult material. This is consistent with the findings in Calvano (1985) but inconsistent with

Dunn (1991). There was no statistically significant difference between any of the three groups of mathematical achievement.

Student responses indicated less than 20% expressed a preference for sound while studying. These responses may indicate a reaction to what has been previously experienced in the classroom or to parent mandates of no music while studying at home. Traditionally, teachers have admonished students for talking during class, not allowing discussion among students other than that which is part of a whole class lesson, or allowing music or other sound while students were working (Dunn, 1991, Center, 1992). Not being conditioned to "approved" sound in the classroom or at home may color student responses.

The discrepancies between the students' responses during the interviews and their profile preferences were very noticeable for the area of noise level. Students even contradicted themselves within the interviews by indicating they liked to work with music and then stating they needed quiet to study. It would appear that one explanation for this discrepancy is the difference between music, which is basically a rhythmic sound that can become an unconscious background noise, and noise from sources such as other students that can become disruptive. My personal experience qualifies this even further with a distinction between the type of music, such as non-recognizable instrumental versus easily recognizable vocal, and the difficulty of the material, or amount of concentration which is necessary.

This area seems to present problems for the students when reporting their own preference. It may be necessary to allow students to experience sound in several different situations so they can differentiate what is necessary for their own needs. The broad area encompassed by the questions involving the preference for sound on the LSI may also contribute to the inconsistencies which students reported.

Light. This subscale produced the greatest discrepancy between preferences. While only about 5% of the students indicated a preference for bright light, at least 50% of the students in each achievement level expressed a preference for dim light while the remainder did not have a preference. Again, traditionally, classrooms have had bright lights, usually florescent. Through personal observation, when areas of the classroom are dim the majority of the students will gravitate toward that area. In fact, if natural light is available in the classroom it is seldom that students will ask for the lights to be turned on.

The fact that just over 5% of the students indicated a preference for bright light is very significant. Since most classrooms have florescent or bright lighting which is continuously illuminated many students are working under conditions which may affect their ability to learn difficult material. The issue of brightness was first brought to my attention by students who complained that the brightness of the computer screen was hurting their eyes. Adjusting the brightness alleviated the problem.

Several studies with experimental design have shown that students achieve better when their preferences are accommodated (Krimsky, 1982; Hodges, 1984; Miller, 1985; Gardiner, 1986; Smith, 1987). The number of students who indicated a preference for dim light coupled with the small percentage who expressed a preference for bright light make a compelling argument for adjusting this environmental factor.

Design. Though there was not an overwhelming preference for an informal design by any achievement level, 41.5 percent of the high achievement level students indicated a preference for an informal design in contrast to only 31.7% of the Chapter 1 students. Over 50% level had no preference for design.

Several of the students stated they preferred being comfortable while studying, giving examples such as lying on a couch or bed. Only one student indicated she preferred sitting at a desk. As with the other areas, informal design is seldom found in a traditional middle school classroom. Students who have not experienced options which indicate acceptance of alternative styles may not give them consideration. In other words, if the teacher has not provided options for accommodating different learning styles and given indications that departures from the traditional classroom are acceptable, the students may not consider such alternatives as sitting in a bean bag or listening to music during a class when identifying their learning style.

An experimental study involving design found that students' mathematical achievement and attitudes could be significantly affected when matched with their preference for design (Hodges, 1984). With about 45% of the students expressing a preference for either informal or formal design classroom modifications which accommodated student preferences could easily be accomplished.

Intake. Less than 15% of the students indicated they did not prefer intake while studying. Though over 50% expressed no preference, the remaining 30% preferred intake. Other than chewing gum, which is usually a staple of middle school students, opportunities for intake during the school day are limited. Few students take advantage when presented with opportunities for intake during class.

Mobility. Less than 16% of the students indicated they did not prefer mobility, while 36% expressed a preference for mobility. Though it was mentioned, mobility was not perceived as a high priority for the students in interviews.

Research reviews have indicated the need for mobility by students can result in the misdiagnosis of such problems as hyperactivity, classroom disruption, and low academic achievement and can have a negative effect on low achieving students (Dunn, 1989; 1991). Again, the traditional classroom has not provided for mobility. Activities such as going to the pencil sharpener were about the extent of mobility. Many students took advantage of this opportunity, even to the point of breaking their pencil so they might have a legitimate reason for movement. Providing activities and opportunities for mobility in the classroom will allow students who require movement to fulfill that need.

In each subscale the highest percentage of students who comprised the minority preference was less than 20%. The majority either preferred or had no preference for dim light, informal design, intake, and mobility, all factors which are not found in the traditional classroom. The only factor which was not as clear cut was noise level. Combining the number of students who preferred quiet with those who had no preference accounts for just over 80%. The number who prefer sound combined with the number who have no preference is just over 70%. This was the one area which presented the most discrepancy, not only between the LSI profile and student verbalization, but within responses given by the student.

Summary

This study used inferential and descriptive statistics to determine if there were a relationship between mathematical achievement and learning styles or if there were a statistically significant difference between the learning styles of Chapter 1 students and average and high achieving students. No statistically significant difference between the groups of mathematical achievement was found. No strong relationships were found through correlations of mathematical achievement and five selected subscales of the LSI. There were three moderate, positive relationships between Chapter 1 students and mobility, average achieving students and light, and high achieving students and design. More than 50% of the students expressed no preference for noise level, design, or intake. Yet, within these areas, the greatest difference occurred between the opposite ends of the continuum. Combined with the students in each area who did express a preference for the non-traditional choice, there was an clear indication that the traditional classroom does not meet the preferences of students in terms of providing choices for light, design, intake, or mobility, regardless of level of mathematical achievement. Though 30% of the students expressed a desire for quiet, this still left 70% who had no preference or a preference for sound. This distinction was further clouded by conflicting responses given by students in interviews.

Discussion

This study has resulted in a plethora of questions about testing instruments, learning styles, mathematics, and Chapter 1 students. Discussion of these follows.

Instrumentation

There are several factors which may have influenced the results which were found in this study. The first concern would be the instrumentation. The instruments used in this study were the ITBS, a standardized test which was used to measure mathematical achievement and the LSI, a self-reporting inventory to determine learning style preferences.

The fact that the results did not indicate a significant difference in the learning styles of Chapter 1 students and other students in the area of mathematics is colored by the problems incurred in instrumentation and the apparent inability of the students to accurately assess their learning styles through self-reporting.

Standardized Testing. Actual mathematical achievement as determined by standardized tests such as the ITBS, though the most objective, may not be a completely accurate assessment of either achievement or ability. Though the reliability and validity of the ITBS is not in question, as one researcher has observed, "(a) few reliabilities are troublesome, especially those for the computation test M-3, in which for the upper levels the percentage of students completing the test is less than two-thirds." (Willson, 1989, p. 396). Since this test is one of the three tests used to determine the total mathematics score on the ITBS, students who are concerned about the number of questions versus the amount of time allowed may be overwhelmed and fail to work to their potential.

Traditionally standardized tests have been used for their ease in administration and scoring. Through the use of multiple choice questions it was possible to determine a student's knowledge concerning specific facts in a subject area in a relatively short period of time. It was much easier and quicker to grade objective examinations than essays or short answer. And with a "totally objective test" the results could be normed and statistical comparisons made among students at a national level.

Historically, standardized tests assessing mathematics achievement have been timed, multiple choice examinations. These tests "emphasize isolated low level procedural skills at the expense of conceptual understanding and problem solving" (Stenmark, 1991, p. 8). Timed tests measure how quickly a student can respond and do not take into consideration the thinking processes of the student. Mathematical tools, such as calculators, manipulatives, and measurement devices have not been allowed on standardized tests. Strategies, processes, creativity, flexibility, or persistence, all important mathematical behaviors, cannot be measured adequately on such tests.

> Standardized test scores also have drawbacks as tools for instructional diagnosis and decision making. Designed to be independent of a local

> curriculum, the tests cannot give a teacher much help in pinpointing the parts of the curriculum in which a student needs more work. More insidiously, according to critics, the multiple-choice format rewards the teaching and learning of test-taking skills (such as filling in answer-sheet bubbles and eliminating incorrect choices) that have little real-world usefulness and in which students' strengths and weaknesses should be unimportant (U.S. Department of Education, 1993, p. 154).

Results from standardized tests are used for many purposes which include placement of students in special programs, allocation of resources, effectiveness of programs, and comparison of teachers, schools, and districts (Stenmark, 1991). In a study conducted in Arizona in 1988, the majority of respondents, both teachers and administrators, thought that test scores from standardized tests were used for inappropriate purposes (Nolan, Haladyna, & Haas, 1992). As noted previously, selection for participation in Chapter 1 programs is normally determined from results on standardized tests. District wide achievement data are compiled and program evaluation assessments are determined from these test results. Whether this is an accurate determination of ability, achievement, or program evaluation is suspect considering the possibility of score pollution.

Score pollution, used by Nolan, Haladyna, and Haas, to describe situations where test scores are distorted, results from

> (a) the ways that schools and teachers prepare for tests, (b) variations in test administration conditions, and (c) factors residing outside the influence of schooling that are known to influence test performance. (1992, p. 9)

The last factor, outside influence, has critical implications for Chapter 1 evaluation. The cultural background, parental involvement in the educational process, and student attitude toward school all contribute to possible score pollution for the Chapter 1 student. Students are placed in and removed from the Chapter 1 mathematics program by standardized test scores. Score pollution could be causing children to be placed in a program in which they do not belong.

Learning Styles Inventory. The second instrument used was the LSI. Though this instrument has reported reliabilities on 19 of the 22 subscales of .72 or higher, the self-reporting component presents concerns. It is problematic as to whether self-reporting accurately reflects the student's learning style for middle school students. The student may actually believe s/he learns well in quiet since that is the primary setting in which s/he has learned in the past in school. Or the student may be reflecting what is perceived to be the expected answer. Gregorc spoke to this issue in discussing practical obstacles to learning styles when he said students "might not put down their true position; they put down the socially acceptable one" (O'Neil, 1990, p. 6). In addition, the students may not actually be cognizant of how they learn new and difficult material best. The traditional classroom has not offered options to students while they were learning, it has been very structured. Those students who, either learned best in such a setting or used coping strategies for adjusting to a incompatible environment, usually achieved the best (Decker, 1983). Those students who did not learn best in the traditional classroom setting and did not implement coping strategies became the low achieving students.

Another concern is whether students who have not been presented with choices in their learning environment are able to determine their learning style through a self-reporting instrument. Without previous experiences in different learning environments, for example with sound or mobility, do the students know whether they learn best in a situation which provides these options? Even though they may be given a brief overview of learning styles and view a video prior to administration of the LSI, students may not have had the opportunity to think about how they learn new and difficult material best. They may have an idea of how they might like to work, but it may not actually be how they do learn best. For instance, most middle school students like music and many will indicate they would like to learn or study with music on when asked informally in a classroom situation. They may not have given much thought to whether this is the optimal condition for them since many of them may never have had the opportunity to experience learning under those conditions. Listening to music is something they like to do, so they would like to do it while they are studying. But when asked on a formal instrument such as the LSI they may respond with what they perceive to be the expected answer. This conflict was emphasized in the responses of the students who were interviewed and their contradictions of not only the profile preference but earlier statements within the interview.

Another issue which may be critical to the use of the LSI in middle school is pre-administration preparation and actual administration of the instrument. Students who are not familiar with the formal concept of learning styles may not be able to identify accurately their learning style without extended discussion of the concept and some actual experimentation by them in various environments. Again, the lack of options in the tradition classroom would seem to limit previous opportunities to investigate what works best. Without this knowledge the students may not be able to make accurate assessments of their learning style.

Formal instruction in administering the LSI is not a prerequisite. But as in any test administration, the knowledge, attitude, and demeanor of the administrator can affect the results. Though the teachers who administered the LSI to the student in the middle school which was used in this study had participated in a half-day learning styles workshop they were relative novices with the concept of learning styles and may not have adequately explained the purpose of the LSI to the students so they were aware of how to consider their answers. Whether this was a factor is unknown.

The questions on the LSI may also contribute to inconsistencies in student identification of their learning style. For instance, questions which are not absolute but open to interpretation may encourage students to make choices which later appear to be inconsistent with replies in interviews. Additionally, though the instructions emphasize the student should "decide to what extent you would agree or disagree with that statement if you had something new or difficult to learn" (Dunn et al., 1989b), many of the questions refer to studying, rather than learning. Student perceptions of differences between studying and learning may lead to answers which do not reflect the student's actual preferences when learning new and difficult material. Studying may be equated with home and learning with school, two climates which can be very different. And, since there is no distinction made between studying at home and studying at school, it is impossible to determine whether the student was thinking of home or school when completing the inventory.

The poor specificity of questions is troublesome in evaluating possible reasons for inconsistencies in student reponses. For instance, question 32 refers only to sound but does not denote whether this sound is music, a jackhammer, talking by other students, or simply unobtrusive background sound. (A list of sample questions from the LSI may be found in Appendix A.) Each student may have a different interpretation when answering the question, resulting in an inaccurate assessment of what the student really needs or prefers when studying or learning.

The general lack of clarity associated with the LSI raises concerns about how useful it is in accurately assessing or allowing a student to assess her/his learning style. Though there is a manual available for use, it does not provide comprehensive instructions on administration. Only a paragraph is devoted to administration with information similar to that which is provided on the answer sheet. Studying is equated with learning in the manual but the distinction is not clearly stated in the instructions to the LSI on the answer sheet (Dunn et al., 1989b; Dunn et al., 1989c).

Since this study involved only five subscales of the LSI no generalizations are made about the other learning style subscales, though it may be assumed that the same problems and limitations may exist.

Mathematics Achievement and Instruction

A critical issue that arose in the area of mathematics achievement and instruction concerned the actual assessment of mathematics achievement. The current emphasis on standardized testing as an evaluative method for ascertaining mathematical achievement is imprecise as a conclusive determination of ability or achievement. This is evidenced to some degree by Amanda. Her ITBS score made her eligible for Chapter 1 but she was a conscientious student, enrolled in a regular mathematics class and achieved success. Her verbalization of learning style preferences indicated factors that are present in most classrooms, bright light, sitting at a desk, and auditory and visual explanations. The fact that her preferences were accommodated may account for her success in class work. But it does not account for her low mathematical achievement score. Such factors as student and parental motivation, test anxiety, the testing environment, and personal distractions all have an effect on student performance.

Though the results of this study did not find any significant difference in learning styles between levels of mathematical achievement, it was evident that preferences do occur. The environmental factor of light was the most striking area with only 20 students out of a sample of 382 who indicated a preference for bright light. If this truly reflects the learning style preferences of middle school students than changes must be considered.

My initial interest in this study was stimulated by an observation that many Chapter 1 students appeared to have more success in the areas of mathematics which were spatially oriented. Though this study did not look directly at the issue of global/analytic learning patterns, these preferences may impact mathematics instruction and achievement. Different content areas may meet the needs of different preferences and provide opportunities for success for those students. For instance, the spatial emphasis in geometry as opposed to the abstract nature of algebra would accomodate the cognitive preferences of global students. This would indicate that instructional strategies should account for these differences in preferences so students may experience success in all areas.

Another factor which may account for the success which occurs in classrooms where learning styles are facilitated is the instructional ethos of the teacher. A teacher who has accepted the concept of diversity of learning styles and encouraged students to work in an environment which is conducive to their learning style may impact the classroom climate in a way that is reflected in student achievement and LSI preferences. It is probable that teachers who embrace learning styles also implement a number of other alternative instructional strategies in their classes. They are open to change, embrace diversity, and provide an atmosphere of acceptance, factors that influence the classroom climate. In addition, students who have had the opportunity to experience choices in the classroom environment may be more likely to have a more accurate assessment of their own learning style and consequently can articulate this awareness through self-reporting methods such as the LSI and interviews.

Chapter 1 students

As noted earlier, most students are identified for placement in Chapter 1 programs through results from standardized testing. But this placement does not always occur. This study looked at Chapter 1 eligible students not just students enrolled in Chapter 1. Many parents request to withdraw their student from Chapter

1 classes. The limitation on class size may also prevent all students from being served. Whether differences would have occurred if the Chapter 1 classification used in this study were restricted to only students who had been enrolled in a Chapter 1 mathematics class during the school year is a question left unanswered.

The socio-economic, demographic requirements for inclusion of a Chapter 1 program in a school provide an additional factor that should be considered when comparing mathematical achievement. The students in this study, even if they were not eligible for a Chapter 1 program, were in a school which qualified for a Chapter 1 program. Once the school qualifies for a Chapter 1 program there is no further determination of socio-economic status as a requirement to entitle a student to receive Chapter 1 services. Consequently, the classification of Chapter 1 eligible may include students from all socio-economic levels, as may students identified as high achieving. Conversely, low achieving students who do not live in an area in which the socio-economic level permits inclusion of a Chapter 1 program in the school are not afforded these services. The presumption may still be made that students in a school which has a Chapter 1 program are from an area that overall has a lower socio-economic level than a school which does not have a Chapter 1 program. Therefore, one is not looking solely at students who simply have low achievement scores in mathematics. Consequently, the issue of socio-economic status may have influenced the mathematical achievement and learning style preferences of students in this study.

Students' perception of their ability may also influence mathematical achievement in Chapter 1. They are aware that the Chapter 1 program is for students who have not achieved well. Low self-esteem may be further exacerbated by enrollment in a program such as Chapter 1. Expectations and motivation may decline. Teacher attitude can become a very powerful factor if this occurs. So the question becomes, does placement in Chapter 1 affect learning style preferences or do learning style preferences affect Chapter 1 placement?

The issue of needs versus preferences may actually be a factor in Chapter 1 students. Though it is difficult to differentiate between what may be a need and what may be a preference such factors do exist. A student may score low on a standardized test because the lighting was so bright that it actually caused physical discomfort to the student. This might inhibit the student's performance and result in an assessment which was not determinative of the ability of the student. In this case, dim light would become a need. On the other hand, a student who chose to work in dim light but could compensate when required to function in bright light would have a preference for dim light, not a need.

Consequently, what are regarded as preferences of learning style, particularly as they involve environmental elements, may be needs for some students who become identified as Chapter 1 eligible when these needs are not met during testing or learning situations.

Chapter 1 has the potential to reach and assist many children who might otherwise fail to complete their education. But in assisting these children, the program must consider why the children were placed in Chapter 1, whether the placement is accurate, and the best methods for addressing the educational needs of these children.

Recommendations

The study was limited by a population of middle school students in an urban school in a large metropolitan area in the southwest. Further limitations reduced the population to approximately 50% of the total school population. These reductions were necessitated by the requirements of a consistency score of 70 or above on the LSI, a NCE score for total mathematics on the ITBS given in the district in the spring of 1992, a decision not to include any students who received services in special education, and LSI scan sheets which had illegible identification. Other limitations included determination of mathematical achievement by a standardized test and use of only five subscales from the LSI. Consequently, further research should be conducted to determine if the results of this study occur in other populations. Possible studies are suggested as follows:

1. continued investigation, through qualitative methods, of students' perception of their learning styles as compared to their responses on the LSI;

2. a longitudinal study, determining whether successive yearly administrations of the LSI produce consistent responses and whether these responses are consistent with the students' perceptions;

3. observation of student choices in an environment which accommodates the spectrum of learning style preferences to determine if students make decisions consistent with their LSI responses and verbalized perceptions of their style;

4. a comparison of students' study habits in the home environment, options exercised in a multiple learning style environment, and responses on the LSI;

5. a determination through interviews of whether students' perceptions of what they think are acceptable learning conditions and their own preferences are compatible;

6. teacher interviews to determine their perception of the effectiveness of learning style changes in the classroom;

7. administration of standardized tests consistent with time preferences indicated by student responses on the LSI to determine if this is a significant factor in determining achievement;

8. looking at other subscales to see if students' perceptions and responses on the LSI are consistent;

9. study a larger population to see if cultural and ethnic diversity affects learning style preferences.

10. compare the learning styles and mathematical achievement of students in a Chapter 1 school and students in a school which does not qualify for Chapter 1 services to determine if socio-economic factors may have an influence;

11. interview students about their learning style preferences in other subject areas to ascertain if differences in preferences occur across subject areas.

Administrative and Instructional Implications

The administrative and instructional implications of learning styles and mathematical achievement are so intertwined that it is difficult to segregate them into separate categories. For example, an administrative decision concerning staff development programs about learning styles would also impact the instructional program. Consequently, this discussion will make no attempt to distinguish between administrative and instructional implications.

Although the results of this study do not indicate any relationship between mathematical achievement and learning styles and no statistically significant difference between Chapter 1 mathematics students and average or high achieving mathematics students, I would not advocate dismissing learning styles as ineffective. Learning styles present a philosophy which focuses on the individual student, providing choices so the student has options in discovering how s/he learns best. Obviously by encompassing a philosophy consistent with a focus on the individual the locus of control moves from the teacher to the student. It then becomes incumbent upon the teacher to provide opportunities and options. Students need to be allowed to experience choices within their environments so they may determine which is the most conducive for learning when confronted with new or difficult material.

In addition, this study looked only at the area of mathematics in the middle school. The interviews asked the students to express their learning style preferences in relation to mathematics and their mathematics classroom. There may be differences in students' perceptions of their learning style preferences when they consider different subject areas.

The original impetus for this study was to determine if Chapter 1 students had a different learning style which was not accomodated in the traditional classroom and consequently impede their learning. Although this study did not find that their learning styles differed significantly from those of other students in mathematics, it did indicate the diversity of learning styles among students at all achievement levels. This, in itself, should be impetus to make accommodations for all students in every classroom.

The most important factor about learning styles may be the fact that it causes people to reconsider what has traditionally been the norm for the classroom environment and instructional approaches and strategies. "People are different, and it is good practice to recognize and accommodate individual differences. It is also good practice to present information in a variety of ways through more than one modality..."(Snider, 1990, p. 53). Teachers who recognize and accomodate individual differences facilitate learning.

The financial expense of testing each student for their learning style becomes critical in an era when school budgets are strapped and not every student has a textbook. Though Dunn advocates testing, stating that "teachers cannot correctly identify all the characteristics of learning style" (Dunn, 1989, p. 16), the results of this study cast doubt on the ability of middle school students to accurately assess their learning style through the self-report inventory. The problems which I perceived in the inventory would prevent me from recommending the LSI as an accurate measure of learning styles of middle school students. As indicated from the interviews, students stated their learning style as one modality and then gave descriptions of a completely different modality when elaborating how they learn best. If this occurs in a one to one interview after a self-reporting inventory has been administered, there is reason to believe the preferences indicated on the inventory may not be as accurately reported as one might assume. Providing opportunities for teachers to become informed about learning styles and implement changes in the classroom environment along with a repertoire of instructional strategies might be a more efficient use of any monies provided for a program addressing student learning styles.

It is obvious from the literature that learning styles can create a positive difference in educational situations (Dunn & Griggs, 1989; American Association of School Administrators, 1991). But, as indicated earlier, teacher ethos may be a contributing factor in these assessments. Providing options in the classroom environment, respecting differences, and promoting student autonomy may be effective methods utilized by these teachers that contribute to the positive effects manifest when learning styles are implemented in the classroom.

As educators, it is incumbent upon us to provide a conducive environment for learning. The concept of learning styles asks us to look at how we can make changes that will accomodate student differences, and then implement those changes. This may be the most important function and contribution of learning styles.

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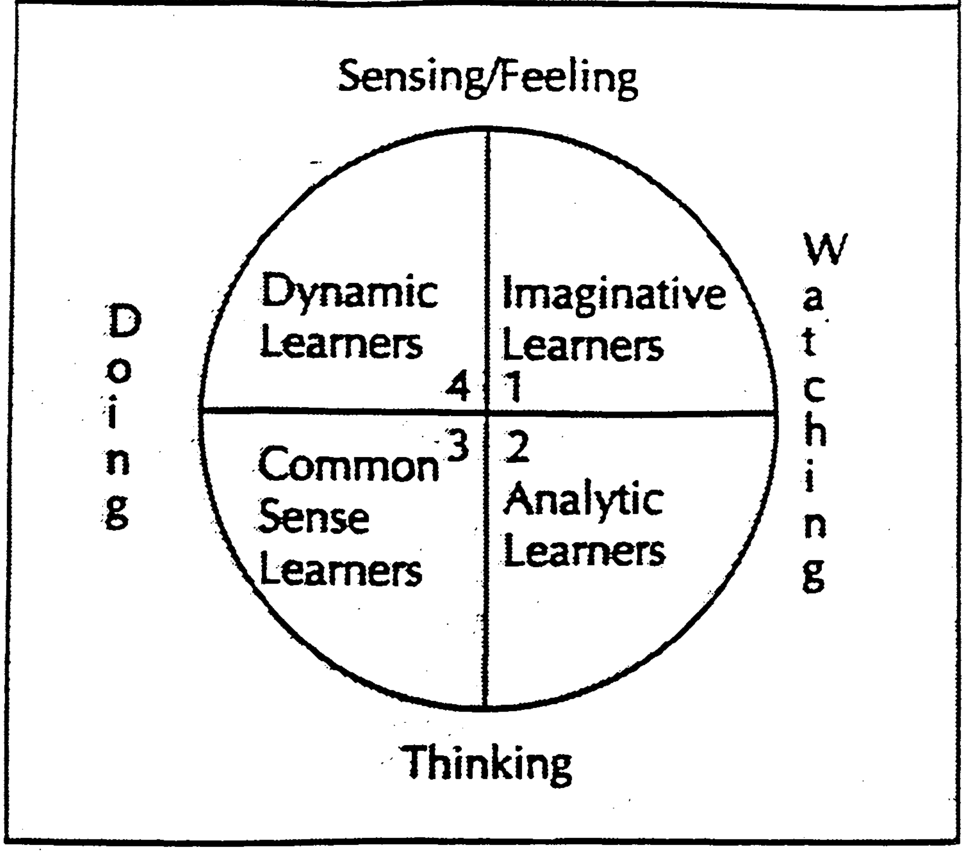
APPENDIX A

LEARNING STYLE MODELS AND SAMPLE LSI QUESTIONS

The Four Major Learning Styles



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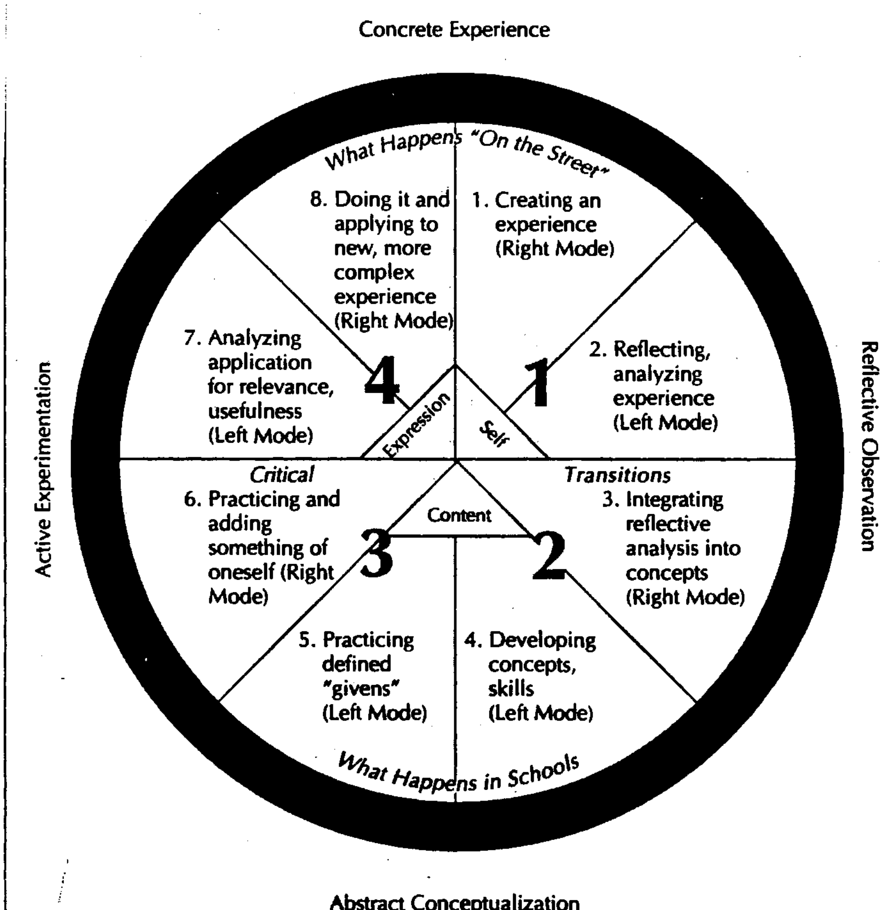
The 4MAT System



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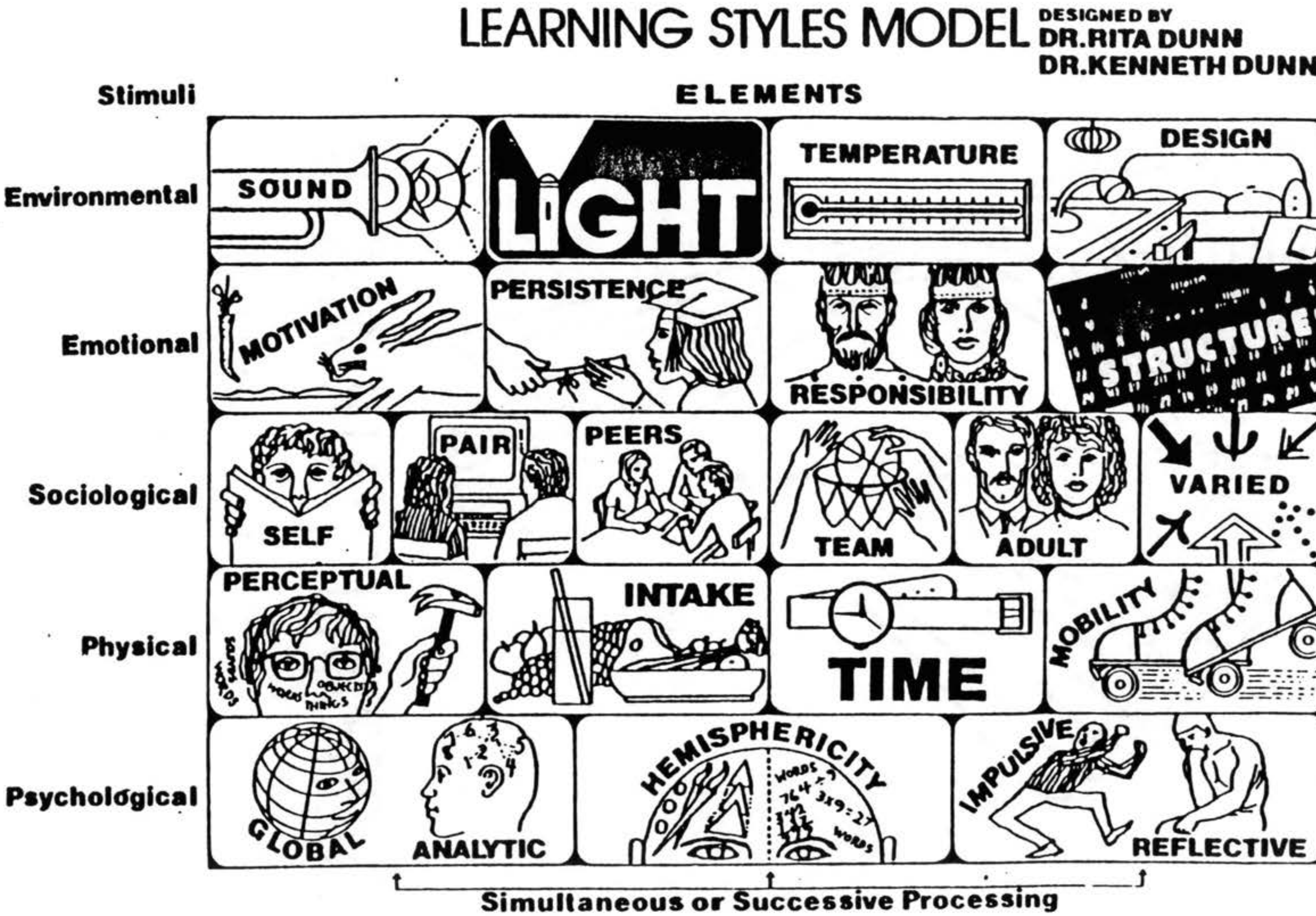
LEARNING STYLES MODEL
DESIGNED BY
DR.RITA DUNN
DR.KENNETH DUNN
Stimuli
ELEMENTS
Environmental
SOUND
LIGHT
TEMPERATURE
DESIGN
Emotional
MOTIVATION
PERSISTENCE
RESPONSIBILITY
STRUCTURE
Sociological
SELF
PAIR
PEERS
TEAM
ADULT
VARIED
Physical
PERCEPTUAL
INTAKE
TIME
MOBILITY
Psychological
GLOBAL
ANALYTIC
HEMISPHERICITY
IMPULSIVE
REFLECTIVE
Simultaneous or Successive Processing

SAMPLE QUESTIONS FROM THE LSI

The following are representative questions from the LSI. The numbers indicate the number of the question in the LSI. Only questions which pertained to the five subscales of noise level, light, design, intake, and mobility are presented. Answers are based on a five point Likert scale.

1. I study best when it is quiet.

3. I like studying with lots of light.

6. I study best at a table or desk.

16. I study best when the lights are shaded.

18. I do not eat, drink, or chew while studying.

19. I like to sit in a straight chair when I study.

22. I think better when I eat while I study.

25. It's hard for me to sit in one place for a long time.

32. Sound usually keeps me from concentrating.

58. I can sit in one place for a long time.

88. I can ignore most sound when I study.

<u>Note</u>. From Learning Style Inventory Answer Sheet, Grades 5 - 12. By R. Dunn, K. Dunn & G. Price, 1990. Copyright 1989 by Price Systems, Inc. Reprinted by permission.

APPENDIX B

RESEARCH APPROVAL

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD
FOR HUMAN SUBJECTS RESEARCH

Date: 05-18-93 **IRB#:** ED-93-097

Proposal Title: THE RELATIONSHIP BETWEEN LEARNING STYLES AND THE MATHEMATICAL ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS: ADMINISTRATIVE AND INSTRUCTIONAL IMPLICATIONS

Principal Investigator(s): Adrienne Hyle, Linda Hall

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved with Provisions

APPROVAL STATUS SUBJECT TO REVIEW BY FULL INSTITUTIONAL REVIEW BOARD AT NEXT MEETING.
APPROVAL STATUS PERIOD VALID FOR ONE CALENDAR YEAR AFTER WHICH A CONTINUATION OR RENEWAL REQUEST IS REQUIRED TO BE SUBMITTED FOR BOARD APPROVAL. ANY MODIFICATIONS TO APPROVED PROJECT MUST ALSO BE SUBMITTED FOR APPROVAL.

Comments, Modifications/Conditions for Approval or Reasons for Deferral or Disapproval are as follows:

MODIFICATIONS:

Please add a statement to the parental consent form informing the parent(s) that the students Iowa test scores and Dunn Inventory scores will be accessed and used in the research analysis.

Signature: Marcia L. Tilley
Chair of Institutional Review Board

Date: May 19, 1993

APPENDIX C

INTERVIEW QUESTIONS AND CONSENT FORM

INTERVIEW QUESTIONS

1. Tell me about your learning style.
2. Tell me how you use your learning style in math class.
3. Please finish this sentence: Math is ...
4. What helps you in math?
5. What hurts you in math?
6. Does your teacher help you in math? How?
7. What do you need to do your best in math?

CONSENT FORM

Dear Parent or Guardian:

I am a math teacher at (*name of school*) working on an advanced degree at Oklahoma State University. As part of my doctoral program I am writing a dissertation on the relationship of learning styles to mathematical achievement. As a component of this study I would like to interview your student ________________________ about his or her learning styles.

The interview will last approximately 15 minutes and will be recorded. All the students will be asked the same questions. All responses will be confidential and the names of the students will not be used in any part of the study.

The student's scores on the 1992 Iowa Test of Basic Skills and the Dunn and Dunn Learning Styles Inventory will be accessed and used in the research analysis.

Participation of your student in this interview is voluntary; there is no penalty for refusal to participate, and you may withdraw your consent for your student to participate in this project at any time without penalty by notifying me at (*name of school - telephone number*).

Sincerely,

Linda A. Hall

Please sign the following and return to (*name of school*) with your student.

I have read and fully understand the consent form. I sign it freely and voluntarily.

____

Parent or Guardian

____

Name of Student

APPENDIX D

DESCRIPTIVE STATISTICS

DESCRIPTIVE STATISTICS FOR 6TH GRADE SAMPLE FOR MATHEMATICAL ACHIEVEMENT AND SELECTED SUBSCALES OF THE LSI

Number of cases 138

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum	2	29	26	30	23	20
Maximum	88	72	69	70	66	65
Range	86	43	43	40	43	45
Mean	47.70	48.65	41.32	44.66	51.83	53.29
Median	46	48	40	44	55	55
Variance	354.48	116.11	65.67	85.80	131.21	119.90
Standard Dev.	18.82	10.77	8.10	9.26	11.45	10.95
Standard Err.	1.603	0.917	0.690	0.789	0.975	0.932
Skewness (G1)	-0.024	0.113	0.575	0.689	-0.712	-1.125
Kurtosis (G2)	-0.233	-0.797	0.225	-0.357	-0.445	0.480
Coeff. of Var	0.395	0.222	0.196	0.207	0.221	0.205

DESCRIPTIVE STATISTICS FOR 7TH GRADE SAMPLE FOR MATHEMATICAL ACHIEVEMENT AND SELECTED SUBSCALES OF THE LSI

NUMBER OF CASES 138

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum	12	29	26	33	27	22
Maximum	99	70	63	76	66	65
Range	87	41	37	43	39	43
Mean	49.37	48.32	43.28	5.89	53.71	52.37
Median	48	49	43	44	55	55
Variance	280.4	124.2	69.2	110.6	79.2	130.5
Standard Dev.	16.7	11.1	8.3	10.5	8.9	11.4
Standard Err.	1.425	0.949	0.708	0.895	0.757	0.972
Skewness (G1)	0.610	-0.017	0.526	0.750	-0.733	-0.696
Kurtosis (G2)	0.548	-1.101	-0.376	-0.361	0.193	-0.568
Coeff. of Var.	0.339	0.231	0.192	0.229	0.166	0.218

DESCRIPTIVE STATISTICS FOR 8TH GRADE SAMPLE FOR MATHEMATICAL ACHIEVEMENT AND SELECTED SUBSCALES OF THE LSI

Number of cases 106

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum	13	27	26	33	29	22
Maximum	96	72	71	73	66	65
Range	83	45	45	40	37	43
Mean	45.16	50.39	43.27	45.53	52.90	51.93
Median	45.00	52.00	43.00	44.00	55.00	55.00
Variance	216.61	113.44	82.07	80.19	86.19	140.76
Standard Dev.	14.72	10.65	9.06	8.96	9.28	11.86
Standard Err.	1.43	1.03	0.88	0.87	0.90	1.15
Skewness (G1)	0.572	-0.184	0.344	0.734	-0.595	-0.766
Kurtosis (G2)	1.019	-0.932	0.271	-0.015	-0.262	-0.402
Coeff. of Var.	0.326	0.211	0.209	0.197	0.176	0.228

DESCRIPTIVE STATISTICS FOR LOW ACHIEVING MATHEMATICS SAMPLE ON SELECTED SUBSCALES OF THE LSI

Number of cases 148

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum	2	27	29	33	23	20
Maximum	42	72	69	73	66	65
Range	40	45	40	40	43	45
Mean	31.50	48.99	42.38	45.83	52.62	52.86
Median	33.00	49.00	40.00	44.00	55.00	55.00
Variance	77.79	101.45	79.01	85.62	108.55	115.73
Standard Dev.	8.82	10.07	8.89	9.25	10.42	10.76
Standard Err.	0.73	0.86	0.73	0.76	0.86	0.88
Skewness (G1)	-1.177	0.084	0.599	0.619	-0.810	-0.841
Kurtosis (G2)	1.172	-0.808	-0.037	-0.177	0.005	-0.010
Coeff. of Var.	0.280	0.206	0.210	.0202	0.198	0.204

DESCRIPTIVE STATISTICS FOR AVERAGE ACHIEVING MATHEMATICS SAMPLE ON SELECTED SUBSCALES OF THE LSI

Number of cases 140

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum	43	29	26	30	25	22
Maximum	57	72	63	67	66	65
Range	14	43	37	37	41	43
Mean	49.51	48.28	42.36	45.15	53.34	52.37
Median	49.00	49.00	40.00	44.00	55.00	55.00
Variance	17.20	129.96	58.59	91.90	86.14	136.38
Standard Dev.	4.15	11.40	7.66	9.59	9.28	11.68
Standard Err.	0.35	0.96	0.65	0.84	0.78	0.99
Skewness (G1)	0.192	-0.056	0.291	0.684	-0.851	-0.852
Kurtosis (G2)	-0.095	-1.136	-0.342	-0.487	0.301	-0.262
Coeff. of Var.	0.084	0.235	0.181	0.212	0.174	0.223

DESCRIPTIVE STATISTICS FOR HIGH ACHIEVING MATHEMATICS SAMPLE ON SELECTED SUBSCALES OF THE LSI

Number of cases 94

	NCE	Noise Level	Light	Design	Intake	Mobility
Minimum	58	29	26	33	25	25
Maximum	99	72	71	76	66	65
Range	41	43	45	43	41	40
Mean	70.11	49.67	43.17	44.85	52.30	52.45
Median	67.50	49.00	41.50	41.00	55.00	55.00
Variance	112.66	129.84	82.06	107.70	108.79	142.06
Standard Dev.	10.61	11.40	9.06	10.38	10.43	11.92
Standard Err.	1.10	1.18	0.93	1.07	1.08	1.23
Skewness (G1)	0.942	-0.086	0.809	0.991	-0.509	-0.880
Kurtosis (G2)	0.071	-0.960	0.272	0.121	-0.541	-0.401
Coeff. of Var.	0.151	0.229	0.210	0.231	0.199	0.227

APPENDIX E

ANOVA TABLES

TABLE 1

ANALYSIS OF VARIANCE FOR MATHEMATICAL ACHIEVEMENT* AND NOISE LEVEL PREFERENCE

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Between Groups	26.346	1	26.346	0.234	0.629
Within Groups	26987.770	240	112.449		

TABLE 2

ANALYSIS OF VARIANCE FOR MATHEMATICAL ACHIEVEMENT* AND LIGHT PREFERENCE

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Between Groups	35.432	1	35.432	0.442	0.507
Within Groups	1924446.324	240	80.193		

TABLE 3

ANALYSIS OF VARIANCE FOR MATHEMATICAL ACHIEVEMENT* AND DESIGN PREFERENCE

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Between Groups	55.213	1	55.213	0.586	0.445
Within Groups	22602.682	240	94.178		

TABLE 4

ANALYSIS OF VARIANCE FOR MATHEMATICAL ACHIEVEMENT* AND INTAKE PREFERENCE

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Between Groups	5.7777	1	5.777	0.053	0.818
Within Groups	26074.707	240	108.645		

TABLE 5

ANALYSIS OF VARIANCE FOR MATHEMATICAL ACHIEVEMENT* AND MOBILITY PREFERENCE

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Between Groups	9.7257	1	9.725	0.077	0.781
Within Groups	30223.254	240	240.645		

*Mathematical achievement was divided into two groups, Chapter 1 and high achieving.

VITA

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Doctor of Education

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