1985

Relationship between the Matching of the Students' Learning Styles with the Teaching Strategies and the Content Acquisition, Development of Intellectual Capabilities, and Attitudes Toward the Subject in High School Bilingual Mathematic Students in a Chicago Public High School

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RELATIONSHIP BETWEEN THE MATCHING OF THE STUDENTS' LEARNING STYLES WITH THE TEACHING STRATEGIES AND THE CONTENT ACQUISITION, DEVELOPMENT OF INTELLECTUAL CAPABILITIES, AND ATTITUDES TOWARD THE SUBJECT IN HIGH SCHOOL BILINGUAL MATHEMATIC STUDENTS IN A CHICAGO PUBLIC HIGH SCHOOL

By

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A Dissertation Submitted to the Faculty of the Graduate School of Loyola University of Chicago in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

May

1985

"BEHOLD, I SEND AN ANGEL BEFORE THEE, TO KEEP THEE IN THE WAY, AND TO BRING THEE INTO THE PLACE WHICH I HAVE PREPARED."

EXODUS 23:20

TO MY COUNTRY, MY FAMILY AND MY FRIENDS FOR WHICH I LIVE IN ETERNAL GRATITUDE AND INDEBTNESS TO MY LORD.

ACKNOWLEDGMENTS

No human task can claim to be the effort of one single person, neither does this dissertation. I am very grateful to all of those individuals who directly or indirectly contributed with their talents, time and support in helping me to carry out this endeavor.

I would initially like to express my appreciation to Dr. Todd Hoover, Chairman of the Dissertation Committee, whose direction, professional expertise, and insight into the research process was instrumental in completing this study. Dr. Diane Schiller and Dr. Barney Berlin, also members of the committee, were of further assistance in sharing their knowledge, experience, and time in the development of this dissertation. I am also very grateful to Dr. Kay Smith, Assistant Dean, School of Education, Dr. Mary Jane Gray, Chairman of the Curriculum and Instruction Department, and Dr. Max Bailey, Associate Professor of Administration and Supervision, for their continuous support, encouragement, and cooperation during my graduate studies at Loyola.

As a genuine expression of gratitude, I want to make a special recognition to my teacher and friend, Dr. Ramon Claudio, Dean of the School of Odontology, University of Puerto Rico. His wise advice for more than a decade, and his continuous encouragement and positive support throughout this project process, made possible this final output. I am also very grateful to Dr. Lillian Ramos, Associate Professor at the Catholic University of Ponce, Puerto Rico, who, likewise offered me continued assistance and encouragment throughout this research. Her help will always be cherished.

I want to thank Dr. James Moffat, Principal of Kelvyn Park High

School, whose cooperation and flexibility made possible the implementation of the experiment. I am also very grateful to my colleague, Jose Collazo, who fully cooperated with me in many ways, simplifying the hard work of the implementation of the instructional units. His cooperation during the months previous to the experiment and during the implementation process was instrumental in completing this project. His contribution will always be appreciated. Thanks to other members of the staff who cooperated as well.

I am specially grateful to Ms. Cindy Benford for her very kind, professional and disinterested effort of proofreading this dissertation.

Thanks to Valerie for the neatness and professional quality of the typing work, and for always having my work on time so that I had never to deviate from my schedule.

Thanks to Nereida, my sister-in-law, for being always present throughout this endeavor to share my joys and hear my griefs.

Thanks to my wife, Elba and my sons, Alvin, Elier and Jose for their patience, encouragement, understanding, support, love, and unselfish sacrifice to let me fulfill my goals.

Thanks to my mother and my father who, through their teachings and prayers, have opened me the way to grow without frontiers and to reach the summit.

Thanks to my friends for never letting me feel alone neither in my best times, nor in my most difficult ones.

Thanks, Puerto Rico, for being my inspiration.

Thanks, my Lord, for all my successes.

VITA

The author, Jose Miguel Rodriguez Matos, is the son of Gregorio Rodriguez and Hipolita Matos. He was born May 8, 1948 in Arecibo, Puerto Rico. He is married to Elba Bonilla and is the father of Alvin, Elier and Jose.

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CHAPTER I

INTRODUCTION

Investigations conducted by researchers and educators on students' learning suggest that student's behavior can be influenced by the teacher, the environment, and other characteristics of the self. The teacher imposes demands upon the students which require them to adapt to a diversity of teaching styles that include a wide range of opposite conditions: from the teacher who is permissive and uncontrolled to the one who is disciplined and controlled, from the teacher who is warm and friendly to the one who is hostile and arbitrary, from the teacher who is pupil oriented to the one who is academically oriented. The environment also imposes conditions to which students have to continuously adapt. For instance, the authoritative nature of the educational system demands students to behave in "unison" like the instruments of an orchestra. In addition, the bureaucracy of the school system decides what students should learn and how they should learn it. There are also other social and cultural demands that students have to deal with.

The different ways in which the students respond to these conditions imposed by the teacher and the environment, as well as the success of some learners and the failure of others in adapting to such conditions, give educators reason to believe that each student has an individual learning style. There is also evidence which provides a scientific framework upon which claims about the idiosyncratic characteristics of students learning can be based. Many researchers have conducted investigations on the function of cerebral hemispheres that strongly suggest that the two sides of the brain perform differentiated functions and that both sides participate in the learning process.

The compatability of learning style and brain research has stimulated many researchers and educators to take a closer and deeper look into the individual student's learning style and to identify the most appropriate teaching strategies that match the unique way in which students learn. These researchers and educators believe that matching the student's learning style with the teaching strategy results in an optimum level of student achievement. But a more profound process of diagnosis about the way in which students learn should take place, and more empirical evidence is needed before we make definite prescriptions about the learning experiences to be chosen and the teaching strategies to be employed. In doing this, educators, will be able to develop the effective approaches and means that demand the complexity of student's learning. Consequently, we will be able to narrow the gap existing between the efforts of educators and the educational institutions, and the expected results in student's achievement.

This study aims to provide empirical evidence about the relationship between the matching of the student's learning style with the teaching strategy as it relates to the variables of content acquisition, intellectual capabilities, and attitudes toward the subject of Hispanic bilingual mathematic students of a senior high school.

Definition of the Problem

The problem to be addressed in this study can be stated in the following way: Is there a significant difference between the matching of the student's learning style with the teaching strategy and content acquisition: facts, concepts and generalizations; the development of intellectual capabilities: observation, inference (predictive, generalizing or explanatory), and the attitudes toward the subject in high school mathematic students of a selected bilingual program?

Sub-problems:

1. Is there a significant difference between the matching of the students' learning styles with the teaching strategy and the acquisition of content: facts, concepts and generalizations?
2. Is there a significant difference between the matching of the students' learning styles with the teaching strategy and the development of intellectual capabilities: observation and inference (predictive, generalizing or explanatory)?
3. Is there a significant difference between the matching of the students' learning styles with the teaching strategy and the attitudes toward the subject?

Overview of the Problem Background

The 1970's witnessed one of the most dramatic changes in policy and practice in the educational institutions in the United States. Under pressure from ethnic minorities for equal educational opportunities, the courts demanded compliance with civil rights legislation, and Congress, in 1968, passed the Bilingual Education Act.[1]

The Bilingual Education Program is a transitional program in which non-English speaking children are taught by means of their dominant language while they acquire skills in the use of the second language. Bilingual education builds upon the skills and strengths of the bilingual child. The bilingual program focuses on five broad areas: language skills, knowledge and concepts, application of knowledge and concepts, development and reinforcement of attitudes, and social functionality. Based on those five areas, the basic elements of the program are intensive instruction in English, instruction in subject areas in Spanish, e.g. mathematics, science and social studies, and the reinforcement of pupil use of his Spanish language.[2]

A well-known controversy has surrounded the philosophy, the goals, and implementation of bilingual education programs. Some educators favor the assimilistic notion of the American melting pot. On the other hand, most professionals in bilingual education favor a pluralistic notion. The goal of the latest concept is to yield people who are literate in two languages, who are prepared for the demands of life in a competitive technological society, but who are knowledgeable of and free to retain their cultural identity. Whether students should be taught through their mother tongue or through the English

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[1]This law was amended in 1974.

[2]Aspira, "Special Circular #32, 1974."

language, and whether the broad areas and basic elements mentioned above have been appropriately emphasized or balanced, have been subjects of controversy as well.[3] Either the assimilistic notion or the pluralistic notion requires an in-depth study and diagnosis of students' characteristics before any prescriptions are made about the curriculum, the instructional materials, or the teaching strategies to be used. But most of the controversy between those who favor the bilingual education and those who are opposed to it, is based on subjective judgements and biases about the program, rather than on empirically based information or evidence that sustains the arguments against the program.

Although some studies have been conducted in an effort to determine the strengths and weaknesses as well as the effectiveness of bilingual education, these studies have been primarily concerned with the linguistic performance of the students. Vazquez (1974) summarizes bilingual education in New York in these terms: "...its current, sole concern is with the linguistic performance of the pupil, thereby, neglecting the implementation of a coherent conceptual system which considers the way in which the student comes to relate to the world around him."[4]

The scene described in the statement above has not been

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[3]In depth discussion of the controversy surrounding the bilingual education is beyond the scope of this study.

[4]Richard E. Baecher, "Focusing on the Strengths of Bilingual Children," In Bilingual Education, edited by Herman Lafontaine, et al, (Wayne, New Jersey: Avery Publishing Group, Inc., 1978), p. 249.

significantly changed since 1974 and is applicable to other programs in other parts of the United States as well. The emphasis in the linguistic aspects and social functionality as well as the acculturation process is still the main concern of the bilingual programs and the main focus of research. Much of the research conducted in this subject has been in comparative studies between bilinguals and monoglots, rather than in-depth studies of specific aspects of the programs such as the variables that affect the teaching-learning process that takes place in the classroom setting. Results of the research in the general area of achievement testing have shown that the bilingual child scores significantly lower than the native English speaking child (Floyd, Zintz). But low scores have generally been attributed to or been interpreted as a function of the language barriers and/or the socio-economic status of the child. Other investigators have supported this position. The Coleman Report (1966) found that minority students performed at substantially lower levels than white pupils and that achievement was highly dependent on the pupil's social background.[5]

Some efforts have been made to consider the bilingual students' learning styles as a key variable of the bilingual child. However, no further commitment has been made to study these particular learning styles and their effects in the students' learning (Ramirez and Castañeda, 1974). As well noted by Vazquez, "bilingual education has

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[5]James C. Coleman, et al., Equality of Educational Opportunity (U.S. Government Printing Office, 1966), p. 525.

not been defined as a collective effort for the communication of sound teaching strategies and techniques for the bilingual student."[6]

The concept of learning styles as studied by many researchers and educators provide new alternatives to positively alter the teaching behavior and the learning process not only in the bilingual classroom, but in the regular classroom as well. Gregorc defines learning style as the distinctive behavior which serves as indicators of how a person learns from and adapts to his or her environment.[7] The four distinct patterns or modes defined by Gregorc are Abstract Sequential, Abstract Random, Concrete Sequential and Concrete Random. Rita Dunn defines learning style as the way individuals concentrate on, absorb and retain new or difficult information or skills.[8] According to her, style comprises a combination of environmental, emotional, sociological, physical and psychological elements that permit individuals to receive, store, and use knowledge or abilities. Other researchers define the concept of learning style differently (Debello, Brennan, and Murrai, 1981).

The following documents serve as indicators of the fact that teaching through learning style increase academic achievement: Domeno, 1979; Farr, 1971; Cafferty, 1980; Douglass, 1979; Kremsly,

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[6]Richard E. Baecher, op.cit., p. 249.

[7]Anthony F. Gregorc, "Learning and Teaching Styles," Educational Leadership (January, 1979), p. 234.

[8]Rita Dunn, "Learning Style and Its Relation to Exceptionality at Both Ends of the Spectrum," Learning Style Network (April, 1983), p. 496.

1982; Pizzo, 1981; Carbo, 1980; Urlschot, 1977.[9]

That teaching through learning styles improves students´ attitudes towards school is evidenced by such authors as: Domeno, 1970; Copenhaver, 1979; and Pizzo, 1981. That achieving youngsters in reading and mathematics invariably exhibit learning styles that differ from underachievers is evidenced by these writers: Huds, Saladino, and Meibach, 1977; Dunn, Price and Sanders, 1979; Dunn, Price and Sanders, 1981; and Griggs and Price, 1981.[10] However, none of the work cited above focuses on bilingual education, so questions of whether or not these findings apply to the bilingual child remain still unanswered.

Several learning style inventories have been developed. Among them, Canfield and Cafferty prepared a test that can help in understanding students´ difficulties in completing academic work for purposes of counseling with emphasis on attitudinal and affective dimensions. It measures conditions of learning, content, mode, and expectation of success. Kolb´s Learning Style Inventory measures an individual´s relative emphasis on four basic learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation. The Gregorc Style Delineator suggests that people learn in combinations of four dualities which are: concrete-sequential, concrete-random, abstract-sequential and abstract-random.

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[9]Rita Dunn, "Teaching Students Through Their Individual Learning Styles," Students Learning Styles and Brain Behavior (Reston, Virginia: National Association of Secondary School Principals, 1982), p. 143.

[10]Ibid., p. 144.

The Myers-Briggs Type Indicator measures four preferences: extraversion and intraversion, thinking and feeling, sensing and intuition, and judging and perceiving. The four scores combine to generate sixteen types. The Hills Cognitive Style Interest Inventory measures abstractions, visual, tactile and auditory perceptions, motor coordination, and social interaction. The Dunn, Dunn, and Price Learning Style Inventory is designed to diagnose individual learning characteristics based on the fact that learners are affected by their environmental, emotional, physical, sociological, and psychological preferences. Finally, Cuttel's Sixteen Personality Factor Questionnaire measures the constraints intraversion and extraversion.

More than fifty studies currently exist which report data on students' learning style. At least that same number can be found in the areas of brain behavior or hemisphere domain and their relationship to information processing. The majority of these studies convey significant information about learning style or cognitive style or brain behavior and learning outcomes. When positive results are found, they generally indicate that student learning and achievement can be improved by tailoring instructional methodology wherever possible to each student's style. Much, however, remains to be accomplished. Researchers must continue to build a solid research base for a fuller understanding of mind/brain functioning.[11]

Rationale for Present Research

Mathematics has its own body of knowledge which requires

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[11]Scott D. Thompson, "Next Steps." Ibid., p. 20.

particular attention to the best teaching strategies in which that knowledge can be transmitted through the individual student's learning style.

> It is often argued that minority students are not interested in mathematics or academics in general.... It is true that mathematical disability is more common among minority students, but no study has shown that this is in any way related to sex, race or cultural background.[12]

This statement is a suggestion for the study of other elements or variables that would provide empirical evidence about the reasons or factors that cause students to score low in the achievement tests of the bilingual mathematics program. The literature in bilingual education is quite extensive, but little of it is concerned with mathematics teaching per se. On the other hand, we know that the literature related to teaching and teacher effectiveness is quite extensive also, but little has been done to relate the teacher strategy with the students' learning styles. It is also known that teachers make a difference in student learning and that the influence that teachers have is sometimes significant.

Research conducted in bilingual education and in the subject of high school mathematics teaching, focuses on broad aspects such as general students' achievement, acquisition of language skills, cultural adaptation, social functionality, etc. Such research does not provide clear guidelines for the improvement of bilingual mathematics. Basic questions have not been addressed such as: What are the bilingual students' unique learning styles? What are the

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[12]William M. Perel, "Mathematics in Bilingual Education," Bilingual Education, p. 327.

appropriate teaching strategies that better match the students' learning styles? How is this matching related to students' achievement in the cognitive domain and in the affective domain as well? Answering these questions and substantiating answers with empirical evidence might open the way for the discovery of effective means of teaching high school mathematics to bilingual students. If the findings of the present study show a significant relationship between the matching of the student learning styles with the particular teaching strategy employed by the teacher and the fact attainment, concept attainment, development of intellectual skills, and of attitudes of the group of students under study, then,this study could be a cornerstone for the implementation of sound changes to improve the teaching of mathematics to bilingual students.

Research Questions

This study is investigating the relationship between the matching of the students' learning styles with teaching strategies as a function of and content acquisition (facts, concepts and generalizations), the development of intellectual capabilities (observation, inference, and prediction), and attitudes toward the subject of bilingual students in a selected high school mathematics program. Based on this statement the research questions can be stated as follows:

1. What is the relationship between the matching of the students' learning style with the teaching strategy and content acquisition: facts, concepts, and generalizations in high school bilingual mathematic students as measured by an achievement test?

2. What is the relationship between the matching of the students' learning style with teaching strategy and the development of intellectual capabilities: observation and inference (predictive, generalizing or explanatory) in high school bilingual mathematics students as measured by an achievement test?

3. What is the relationship between the matching of the students' learning style with the teaching strategy and the attitudes toward the subject in bilingual mathematics students as measured by an attitude inventory?

Summary

The concept of learning styles acquires a particular significance when it is studied within the context of bilingual mathematics education. The bilingual program focuses on five broad areas: language skills, knowledge and concepts, development and reinforcement of attitudes and social functionality. The basic elements of the program are intensive instruction in English, instruction in subject areas in Spanish, e.g. mathematics, science and social studies, and the reinforcement of the pupils use of their Spanish language. Since the Congress passed the Bilingual Education Act in 1968, the goals and objectives of the bilingual program have been surrounded by a controversy. This controversy consists of the assimilistic notion of those who believe in the concept of the American melting pot, and the pluralistic notion that is to yield people who are literate in two languages, prepared to compete in a technological society while maintaining their cultural identity. Either one of these approaches requires in-depth study and diagnosis of the students' learning characteristics before any prescriptions are made about the curriculum, the instructional materials, and the instructional strategies to be employed by the teacher.

Research conducted in bilingual education has not taken into consideration the bilingual student's individual learning style as a key component of the bilingual child and its relevance to the teaching learning process. Many researchers and educators believe that the learning style/brain research holds extraordinary potential to significantly improve the professional teacher behavior and the students' learning process. Many studies show that teaching through the individual student's learning style increases academic achievement and improves student's attitudes toward school. Among the most recent proponents of the learning style approach are Anthony F. Gregorc, David Kolb and Rita Dunn.

Mathematics has its own body of knowledge which deserves particular attention. However, very little research has been conducted in this subject as it relates to bilingual students. More research is needed to find out the best teaching strategies that better fit the unique characteristics of bilingual mathematics students. For this reason this study is committed to investigate the relationship between the matching of the student's learning style with the teaching strategies and the content acquisition, the development of intellectual capabilities, and the attitudes toward the subject of high school bilingual mathematics students.

Limitations

1. This study does not focus on the entire bilingual population

so the results and findings apply only to the particular group under study.

2. Reliance on the use only of one learning style inventory exclude other variables that could be representative of students' learning styles.

3. The authoritative nature of the educational system might have influenced students to think of adapted behavior as their preferred learning style; so prescriptions could be made upon the wrong diagnosis of students' natural way of learning.

4. The teacher's attitude toward the subject or toward the concept of diagnosis/prescription itself drastically influences both instrument interpretation and consequent prescription.

Definition of Terms

1. Bilingual education - a program by which a person learns and reinforces his own language and culture while at the same time acquires the ability to function in another language and behave on occasion according to the patterns of the second culture.[13]

2. Bilingual student - a student who is able to function effectively in two languages (for the purpose of this study the two languages are Spanish and English).[14]

3. Teaching strategy - method of instruction that meets the

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[13]Board of Education, City of Chicago, A Comparative Analysis (Chicago: Department of Research and Evaluation, 1975), p. 4.

[14]Board of Education, City of Chicago, A Handbook of Curriculum Models (Chicago: Department of Curriculum, 1976), p. 2.

range of the learners' preference or learning style.[15]

4. Content - knowledge or information gathered from the world around us and stored in one's brain. It exists in three primary forms: facts, concepts, and generalizations.[16]

5. Facts - the most fundamental type of information which man forms through processing; the type of content which are singular in occurrence; which has occurred in the past or exists in the present; which have no predictive value and which are acquired solely through the process of observation.[17]

6. Concepts - the form or data or content that results from the categorization of a number of observations.[18]

7. Generalization - an inferential statement which expresses a relationship between two or more concepts, applies to more than one event and has predictive and explanatory value.[19]

8. Intellectual Capabilities - capacity for rational and intelligent thought; the act of engaging in activity requiring the creative use of the intellect. It includes the ability to make observations, and, through the use of inference, to generalize, to

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[15]Anthony F. Gregorc, "A New Definition for Individual," National Association of Secondary School Principals (February, 1977), p. 24.

[16]Paul D. Eggen, et al., Strategies for Teaching (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1979), p. 32.

[17]Ibid., p. 36.

[18]Ibid., p. 40.

[19]Ibid., p. 49.

predict and explain events.[20]

9. Observation - the act of recognizing and noting a fact or occurrence.[21]

10. Inference - the act of passing from one proposition statement of judgment considered as true to another believed to follow from that of the former.[22]

11. Prediction - The act of foretelling on the basis of observation, experience, or scientific reason.[23]

12. Attitudes - Subject related affect expressed by the students through different means.[24]

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[20]Ibid., p. 15.

[21]Webster's Ninth New Collegiate Dictionary (Springfield, Mass.: Merriam Webster, Inc., 1973), p. 815.

[22]Ibid., p. 619.

[23]Ibid., p. 926.

[24]Benjamin S. Bloom, Human Characteristics of School Learning (New York: McGraw-Hill Book Company, 1976), p. 77.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter reviews literature in the field of mathematics education in general, and within the context of bilingual education. It also reviews literature on the learning styles approach from the various perspectives of prominent exponents of this concept such as David Kolb, Anthony Gregorc, Rita Dunn and Kenneth Dunn, and Barbara Fisher and Louis Fisher. Carl Jung's theory of psychological types is discussed in this chapter to provide a conceptual scheme to the diverse research of learning style. Several research findings as they relate to the problem under investigation are also discussed in this chapter including the most recent investigations conducted in brain behavior. Finally, the topic of models of teaching is discussed based on the work of Bruce Joyce and Marsha Weil.

Mathematics Education

The study of teaching and learning of mathematics must be based on certain assumptions about the nature of mathematics itself. For example, mathematics is: a body of knowledge to be learned, a language using a particular notation, the calculating procedures needed for applications, a set of techniques to be tested by examination, a study of underline logical structure, the construction of models useful in science, an artificial game played by mathematicians.[1]

All these assumptions, however, take place within a social, economic, and cultural background. Thus, the current issues and problems of mathematics teaching reflect the issues and problems of the society at large. The society demands and needs people knowledgeable enough to compete with the technological advances. This knowledge needs to be communicated to others and to be applied not only to other fields, as science, but to the daily realm of a consumer society. To the extent that mathematics teaching and learning is improved, the more the society will benefit from that input. From this point of view, all sectors of society should benefit the most in order to contribute to the overall improvement of society.

Many issues and conflicts arise from different approaches to the teaching and learning of mathematics. What are the goals and objectives of mathematics education? What is the most appropriate content to fulfill those goals and objectives? What kind of learning experiences are most suitable to students' learning capabilities, needs, and interests? There is no one single answer to any of those questions, but they certainly place a burden on the teacher who has to make constant adjustments to respond to the diversity of demands of the students, the parents, the school, the community, and the society. The issues and problems surrounding the mathematics education arise, not only from the particular nature of mathematics, but from pressures

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[1]Ralph Schwarzenberger, "Current Issues and Problems in Mathematics Teaching," in Michael Cornelious, ed., Teaching Mathematics (New York: Nichols Publishing Company, 1982), p. 3.

from within and outside the school.

Schwarzenberger mentions some psychological issues related to math education. One of these issues is the danger of emphasizing the fact that mathematics consist of answers to problems.[2] This notion can prevent the student and the teacher from achieving long term goals. Secondly, there is a danger of emphasizing the fact that mathematics consists of a collection of abstract structures.[3] This could lead to avoiding concrete examples and to regard mathematics as meaningless. Mathematics is regarded as something that people <u>do</u> as well as something that people <u>learn.</u> This means that the teacher must encourage play and discovery rather than passive recitation, must encourage comparison and discussion of different methods or answers, and must react to the different responses of each individual pupil. It follows that every pupil has a potentially different curriculum, and that the requirements of the pupil and of the class might well conflict.[4] At the same time different approaches or strategies have to be employed by the teacher.

The approach of providing for the diversity of students' interests, needs, and backgrounds has become more complicated over the years due to the move away from selective schools during the early 1970's to the hetereogeneous grouping. "Mixed ability teaching is viewed by some mathematics teachers as a challenge, by others as a

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[2]Ibid., p. 7.

[3]Ibid., p. 7.

[4]Ibid., p. 8.

threat; but all are agreed that its adoption calls for a reappraisal of classroom organization, teaching methods, and materials."[5] During the late 1960's a new modern mathematics approach was adopted; during the early 1970's new individualized learning programs were developed which were adopted by the end of the decade; during the early 1980's microcomputing was already in use. All these different approaches and methods have come in an effort to respond to the individuality of students' learning and the mixed ability.

An approach for teaching mathematics called the discovery approach was developed during the 1960's. In brief, discovery means that the student recognizes some mathematical properties or relationships through his own effort.[6] It also means growing awareness of mathematical principles and relations by the students' own effort. Discovery is an experience of exploration. It means invention of mathematical forms and ideas, it means creativity of operations and explanations of new mathematics. Discovery also means testing and proving by means of more examples until principles are unquestionably tested. The discovery approach is a means of growth, for it opens new fields and encourages the construction of new disciplines. Discovery "is a kind of methodology which pervades the whole process of teaching and which encourages student contributions from most experiential and simple beginnings to considerations of a more profound nature, and then seeks the cooperative help of the

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[5]Ibid., p. 50.

[6]Harold P. Fawcett, et al., <u>The Teaching of Mathematics From Counting to Calculus</u> (Columbus, Ohio, 1970), p. 48.

student to organize the knowledge into a local system."[7]

The teaching of concept is central to mathematics instruction. Difficulties in forming conceptual structure is probably one of the basic problems in learning mathematics. Concept formation is a far more complex task than the ability to perform routine operations. A student could perform the mechanics of solving an equation and not grasping the meaning and structure involved in that operation. According to Piaget, the development of a concept by a child is dependent on mental activity that takes place as he experiences and interacts with his environment.[8] Concept development can be directed, however, by providing pupils with materials that exemplify the relationship, which, when abstracted, becomes the concept.[9] To make concepts fully operational the teacher should present pupils with as great a variety of situations as possible that exemplifies the concept.[10]

Another aspect of primary importance in the teaching of mathematics is the attitude toward the subject. Many people define attitude differently. For the purpose of this study it can be defined as a predisposition to react positively or negatively to the subject of mathematics or to any mathematics object or task. The attitudes

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[7]Ibid., p. 51.

[8]For a complete description of Piaget's theory see: Piaget, "The Stages of Intellectual Development of the Child," in H. Munsinger, ed., Readings in Child Development (New York: Holt, Rinehart and Winston).

[9]Op.cit., p. 67.

[10]Ibid., p. 69.

and emotional reactions are seen as a function of the kind of satisfactions that students derive from his mathematical experience. Unpleasant early experiences may result in negative attitudes toward mathematics subjects in later courses. These experiences are shaped by the type of content chosen to attain the curricular goals, the learning experiences and the teaching strategies employed by the teacher, and the attitudes of the teacher toward the learner and the math subject. To the extent to which the mathematics subject is challenging enough to arouse the students' interest and active participation without being threatening, learning will be more effective as well as the development of more positive attitudes.

Mathematics Within the Bilingual Context

There are three variables of primary importance in the mathematics teaching in bilingual programs: the language of instruction, the inclusion of appropriate cultural referents, and attention to the cognitive styles of the children involved.[11]

Mathematics instruction in some bilingual programs is English based. In other bilingual programs, students receive mathematics instruction in their native language from time to time, but in most bilingual programs the non-English speaking children receive their mathematics instruction in their mother tongue. Some educators argue that children who learn basic computational skills in a language other than English have difficulties in learning more advanced mathematics

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[11] James C. Lovett, Resources for Teaching Mathematics in Bilingual Classrooms (Columbus, Ohio, 1979), p. 3.

concepts in English.[12] This statement has been refuted by research conducted in the United States,[13] as well as in Canada[14] which provides evidence that under appropriate conditions, children who learn mathematics in either their first or second language are not disadvantaged when they switch to the other language.

At the high school level, the language of instruction depends on the students' individual backgrounds, their rate of proficiency in the English language, and the nature of the program. It should be noted, however, that according to the regulations of bilingual education in the State of Illinois, "no program may provide less than 90 minutes of instruction daily through the native language of the students enrolled in the program."[15]

The second aspect mentioned earlier which plays an important role in bilingual mathematics instruction has been called the cultural referents. The term culture is used to mean "the collection of social traditions, habits and values which are reasonably identifiable as shared by some group of people. This includes child-rearing and socialization practices, interpersonal relationships within the family

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[12] M.R. Saville, and R.C. Troike, A Handbook of Bilingual Education. Quoted in Ibid., p. 5.

[13] A.D. Cohen, A Sociolinguistic Approach to Bilingual Education. Quoted in Ibid., p. 5.

[14] M. Swain, and H.C. Barik, Bilingual Education for the English Canadian: Recent Developments. Quoted in Ibid., p. 5.

[15] State Board of Education, Rules and Regulations for Transitional Bilingual Education (Illinois Office of Education, 1976), p. 3.

as well as the larger community, and such things as tastes in food, clothing, music and so on."[16]

A curriculum which intends to be meaningful to the students of the bilingual program as well as the teaching strategies employed by the teacher takes place in a cultural context. So, the teacher has to search for the most meaningful learning experiences and the most appropriate techniques that better respond to the uniqueness of students' culture and background. This implies that the learning experiences must be different for different ethnic groups due to the particularities, for example, among the Puerto Ricans living in New York, the Mexicans living in the Southwest coast or the Cubans living in Florida.

Although the concept of learning style will be broadly discussed in this work, it is appropriate to quote Messick's perception for the purpose of this discussion. He states: "they are conceptualized as stable attitudes, preferences or habitual strategies determining a person's typical modes of perceiving, remembering, thinking, and problem solving. As such, their influence extends to all human activities that indicate cognition including social and interpersonal functioning."[17] A distinction is made between cognitive styles and abilities. Abilities refer to càpacity in terms of level of performance in the content areas, while styles refer to modes of operation across abilities.

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[16]Lovett, op.cit., p. 7.

[17]Messick, "Personality Consistencies in Cognition and Creativity," Individuality in Learning (San Francisco, 1976), p. 5.

A cognitive style dimension called field independence/dependence was developed by Witkins et al.[18]

Lovett identifies three aspects as relevant to teaching mathematics in the bilingual classrooms: structure/guidance, social context, and human relations.[19] Field-dependent children may learn mathematics more readily in relatively structured situations with a high degree of teacher guidance. These are approaches when end outcomes are clearly specified and explicit directions are given as to how they may be attained. Field-independent children, while able to learn in this type of situation, may learn mathematics just as readily (and perhaps even more so) in relatively unstructured, low guidance situations.[20]

People who differ in cognitive style also appear to differ in their view of the social content of a situation. Field-dependent children seem to have an outlook which favors the learning of material with a relatively high degree of social content (material involving people and relationships between people). The outlook of field-independent individuals, on the other hand, tends to favor learning material that can be characterized as impersonal and which requires analytic as opposed to social skills. It would appear that field dependent children, and consequently, many children from cultural

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[18] H.A. Witkin, et al.,"Field Dependent and Field Independent Cognitive Styles and Their Educational Implications," Review of Educational Research, 1977, pp. 47, 1-64.

[19] Lovett, op.cit., p. 9.

[20] Ibid., p. 9.

minorities may be less oriented toward the learning of mathematics than is the case for field-independent children.[21]

These statements suggest a particular effort from teachers and curriculum makers to select learning experiences relevant to the daily life realm of students. Field-dependent students generally prefer working in a cooperative relationship with others to accomplish various tasks; field-independent children, in contrast, tend to be competitive and prefer working independently.[22] These statements are consistent with both, field-dependent and field-independent children preferences to work in social content situations or impersonal situations. Ramirez and Castañeda found that Mexican-American children had more tendency to be field-dependent than children from the middle class culture of the United States.[23]

The implications of the learning style approach to the teaching of mathematics in bilingual classrooms are many. They require a collective effort of all of those involved in bilingual education to identify the individual student learning styles and a careful study of the students´ culture and background in order to provide meaningful learning experiences within that context. The teaching approaches have to be matched according to the students´ peculiarities, the content chosen, and the learning experiences to be provided.

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[21]Ibid., p. 9.

[22]Ibid., p. 10.

[23]M. Ramirez and A. Castaneda, Cultural Democracy, Bicultural Development and Education, Quoted in James Lovett, Resources for Teaching Mathematics in Bilingual Classrooms (Columbus, Ohio: ERIC Clearinghouse for Science, Mathematics and Environmental Education, January, 1979), p. 8.

Learning Styles

Research in the field of learning styles shows that people think and learn in different ways. It also indicates that individual styles reveal how individuals identify, judge, substantiate, confirm and validate truth.[24] However, educators still continue developing programs through the implementation of the conventional teaching strategies not taking into consideration the students' learning styles. Consequently, education is, in many cases, making an insufficient impact in the students' learning. This fact has motivated many researchers and educators to study the concept of learning styles more deeply in an attempt to respond to the individuality of student's learning.

A prominent researcher in the area of learning styles, David Kolb, developed a theory identifying a four stage cycle. Kolb's theory is called experiential because of its emphasis on experience in the learning process. This theory has been labeled as circular because learning begins with experience and ends with new experiences, and has been labeled dialectic because learning requires abilities that are opposites (concrete/abstract; active/reflective).

Experiential learning is conceived as a four stage cycle: (a) immediate concrete experience is the basis for (2) observation and reflection; (3) these observations are assimilated into a theory from which new implications for action can be deduced; (4) these implications or hypotheses then serve as guides in acting to create

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[24]Anthony F. Gregorc, "Learning Style/Brain Research: Harbinger of an Emerging Psychology," Student Learning Styles and Brain Behavior (Preston, Virginia: NASSP, 1982), p. 5.

(RO), Abstract Conceptualization (AC), and Active Experimentation (AE). The learner must be able to involve himself fully, openly and without bias in new experiences (CE), he must be able to reflect on and observe these experiences from many perspectives (RO), he must be able to create concepts that integrate his observations into logically sound theories (AC), and he must be able to use these theories to make decisions and solve problems (AE).[25]

These four learning modes combined to form four learning types: Converger, Diverger, Assimilator and Accommodator. A description of the learning modes and the learning style they form when combined is presented on the next page.

Another researcher in the area of learning style, Anthony Gregorc, argues that: "If educators are to successfully address the needs of the individual learner, they must understand what the word individual means. They must relate teaching to individual learning preference."[26]

Contrary to the popularized conception of the word "individual" as meaning singleness, oneness, uniqueness or specialness, the real meaning of the word (as it applies to teaching and learning), Gregorc argues, lies in the two parts in which it is comprised: indi (non-divisible) and dual (duality). According to Gregorc, educators have failed to distinguish and identify the dualities.

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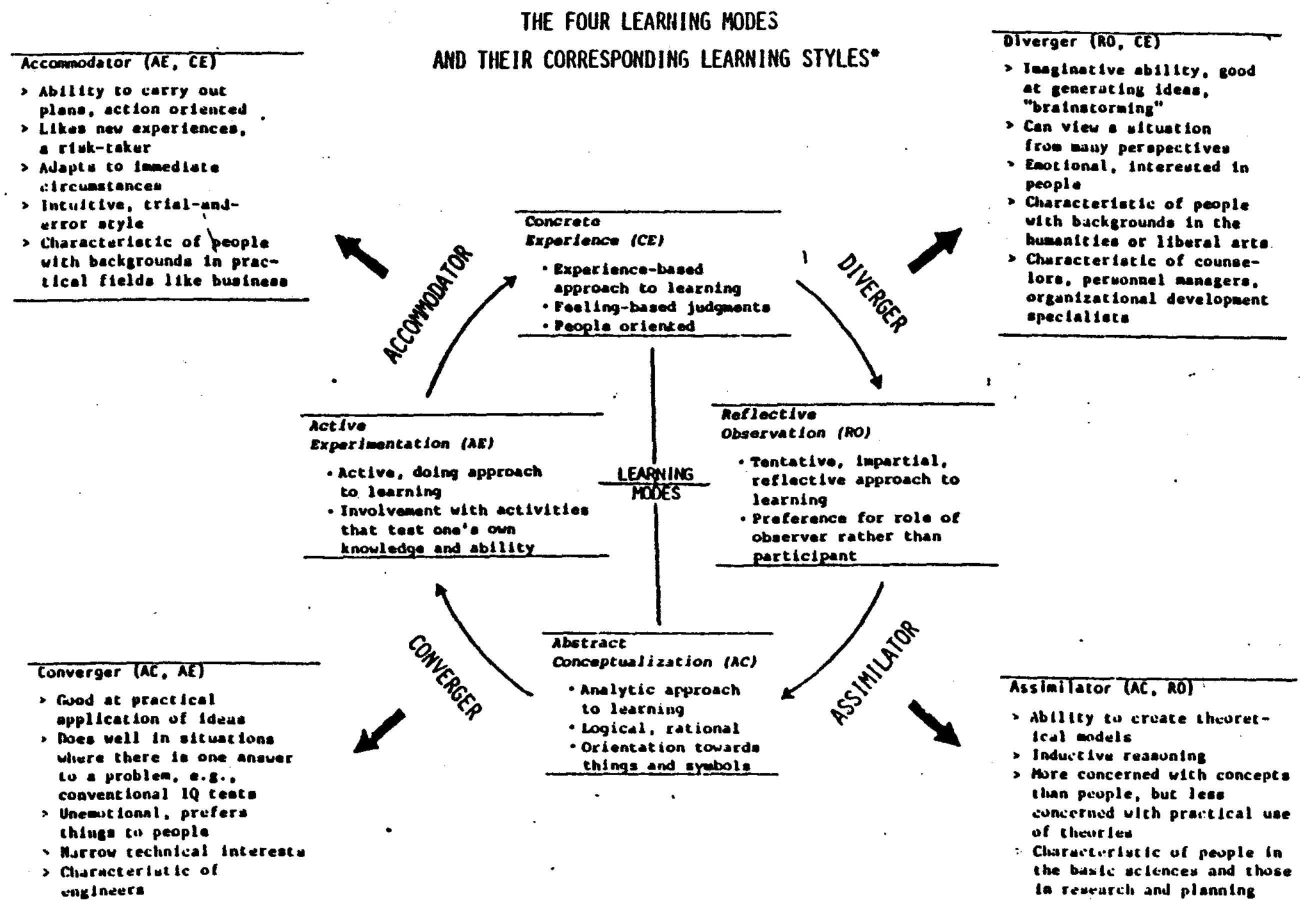
[25]David A. Kolb, Learning Style Inventory: Self Scoring Test and Interpretation Booklet (Boston, 1976).

[26]Anthony F. Gregorc, "A New Definition for Individual," NASSP Bulletin (February, 1977), p. 20.



[27]Adapted from David A. Kolb, "Learning Style Inventory: A Self-Description of Preferred Learning Modes" (Boston: McBer & Co., 1977).

> We hint at dualities when we talk about the educational pendulum swinging ´back to basics´ to relevance curricula; from homogeneous grouping to heterogeneous grouping, from open to closed classrooms. But we fail to identify the dualities in man which are being approached or abandoned.[28]

The concept of inseparability refers to genuine balance and reconciliation of dualities rather than merely coexistence. This lack of identification, reconciliation and balance of dualities has stimulated research to observe how these dualities are manifested and how they can be addressed when teaching.

This type of research, Gregorc argues, is phenomenological. It consists of the cataloging of overt behavior (pheno) and the analysis of behavior to determine its underlying cause (noumena). From this, certain inferences are drawn that tell us about the nature (logos) of the learner.[29] His writings suggest a behavioral definition of learning style which he states as: "the distinctive behavior which serves as an indicator of how a person learns from and adopts his environment. It also gives clues as to how a person´s mind operates."[30]

Analysis of overt behavior indicates, according to Gregorc, that some people´s minds operate best in concrete situations while others perform better in abstract situations. Further, some people operate in an ordering preference that is sequential and others operate better in non-sequential patterns. Gregorc found that these sets of dualities joined to form four different learning preference patterns

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[28]Ibid., p. 21.

[29]Anthony F. Gregorc, "Learning/Teaching Styles: Potent Forces Behind Them," Educational Leadership (January, 1979), p. 234.

[30]Ibid., p. 234.

or modes: Concrete Sequential (CS), Abstract Random (AR), Abstract Sequential (AS), and Concrete Random (CR).[31] He found that every person interviewed revealed use of all four modes, a natural function of inseparable dualities. However, 90 percent of the people expressed a definite preference for one or two manners of acquiring information.[32]

Gregorc recognizes that individuals, as learners, have to deal with the physical, environmental, sociological, and emotional factors or elements. He sustains the thesis that the patterns or differences in style appear to be nature/nurture in its roots. Patterns of adaptation to the environment are apparently available to us through our genetic coding system, through our environment and culture, and through the properties of the self or soul, and are used for self-actualization purposes.[33]

It is a common belief that teacher behavior has a direct impact in student's learning. The curriculum, the instructional materials used by the teacher, and the teaching strategies he/she employs places certain demands upon students. All these variables seem to affect the teaching/learning process. In addition, the modification and adaptation to the students' unique way of learning will also impact the teaching/learning process. The curriculum can be made relevant to the learner, the instructional materials can be adapted, and the teaching strategies can be matched to the learning preference of the

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[31]Gregorc, "A New Definition for Individual," p. 21.

[32]Ibid., p. 21.

[33]Gregorc, "Learning/Teaching Styles," p. 234.

Characteristics Inherent in Specific Information Acquisition Preferences

CS	AR
SOURCE PREFERENCES:	SOURCE PREFERENCES:
Concrete-from concrete reality, special objects or actual instances.	Abstract-apart from concrete reality, special objects or actual instances
Sequential-in linear manner; successive connected parts; structure	Random-multiple sources contributing without an apparent aim, flexible structure
BEHAVIOR	BEHAVIOR
Specific use of one or more of the five senses; direct experience	Uses sixth senses for "vibrations"; attuned to body language, color and mood
Sees situations in blacks and whites	Sees situations in grays
Is cognitively-based	Is affectively-based
Accepts official authority	Accepting of person authority, medium in the message
Has direct, practical pay-off orientation	Has multi-sensory personal experience and group orientation
Anticipates "good" performances, gives and expects to receive primarily corrective feedback	Anticipates subjective-personal performance; gives and expects to receive approval feedback
Sees discrete parts	Sees a whole
Follows step-by-step directions, careful attention to detail	Follows broad overarching guidelines under minimal structure, restraint and limitation
Has low tolerance for distraction	Likes a "busy" environment

(Continued)

AS	CR
SOURCE PREFERENCES:	SOURCE PREFERENCES:
Abstract-apart from concrete reality, special objects or actual instances	Concrete-from concrete reality, special objects or actual instances
Sequential-in linear manner, successive connected parts, structure	Random-multiple sources contributing without an apparent aim, flexible structure
BEHAVIOR	BEHAVIOR
Uses conceptual pictures to decode symbols (written, verbal and/or image)	Uses insight, makes intuitive leaps and gets "gist" of ideas or situations
Sees "the answer" to situations	Sees "an" answer or multiple answers to situation
Is analytically cognitively-based	Is cognitively-affectively based
Accepts referent authority (documentation important)	Accepts varying forms of authority if considered legitimate
Has various, hypothetical, theoretical, analytical, evaluative orientation	Has problem-solving, application orientation
Anticipates "excellent" performance, gives and expects to receive primarily corrective feedback	Anticipates mixed performances, gives and expects to receive approval and corrective feedback
Sees models with logical parts	Sees a whole with overlapping parts
Follows overarching substantive, logical guidelines, and general procedures	Follows overarching guidelines with reasonable structure, restraint and limitation
Has low tolerance for distraction	Likes a stimulus rich environment

NOTE: These behaviors are indicators of subtle and potent individual transaction abilities, capacities, and preferences.

From the research of Anthony F. Gregorc, The University of Connecticut.

students. Gregorc states that: "most successful students in a classroom just happen to have adaptive abilities that match the hidden demands being placed upon them by the teaching method."[34] Gregorc suggests the following steps to better match the learning preferences of the broad spectrum of his students. First, the teacher should observe the behavior of the learners and attempt an empirical assessment of the learning preferences present in the classroom. Second, the assessments should be discussed with students for verification and make modification if necessary. Third, the teacher may then attempt to vary class presentation through the inclusion of methods of instruction that meet the range of learners' preferences.[35]

Rita Dunn and Kenneth Dunn have studied the concepts of learning styles from a different perspective. They identify twenty-one elements of learning styles which fall within five broad categories: environmental, emotional, sociolgical, physical and psychological elements.[36] The environmental elements refer to sound, light, temperature, and design. Some people prefer to work in a silent environment while others perform better with noise. Some students perform better when working with bright light while others need low light to do their best. Differences in temperature also affect people differently. There are also preferences as to whether the condition

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[34]Ibid., p. 235.

[35]Gregorc, "A New Definition of Individual," p. 24.

[36]Rita Dunn, "Learning Style and its Relation to Exceptionality at Both Ends of the Spectrum," Learning Styles Network (Jamaica, New York; March, 1983), p. 496.

of the room temperature should be warm or cold. People have also preferences for formal or infomal designs. While some people prefer the conventional organized design of the classroom or library, others prefer to work in opposite conditions.

The emotional elements refer to motivation, persistence, responsibility, and structure. Motivation for academic learning in some learners comes from their own particular interest. If academic learning is not his/her main interest, no one can make the child complete the assignments. Highly motivated students of all ages are better able to overcome selected learning style preferences than those who are unmotivated. Poorly motivated youngsters require that tasks be divided into small segments; they also need positive feedback while learning, frequent--if not constant supervision, and materials they can master.[37] Persistence refers to the student's ability to remain on a task. The attention span varies from student to student. Many students have a high degree of persistence while others have a short attention span. The degree of responsibility for academic learning is also an element of variation from student to student. The nature of the task, the reason for doing it, and with whom you are working determine the preference for a structured or options environment.

The sociological elements of learning style are self-explanatory. Some people prefer to work alone, others in pairs. Others need peers whereas some prefer working with adults; some prefer working in a team, whereas others can adapt to varied ways.

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[37]Ibid., p. 498.

The environmental and physical elements of learning style vary at different stages of life, but the rate at which they develop or change is related directly to the individual's maturation and physical condition.[38] The physical elements are the perceptual strengths (auditory, visual, tactile/kinesthetic), intake, time of day or night and mobility vs. passivity. An auditory learner can remember approximately 75 percent of what is discussed in a 40 to 50 minutes class. A visual learner can remember approximately 75 percent of what he/she has read or seen during a 40-50 minutes session. More people are visual than auditory in style. Tactile/kinesthetic refers to the learner's preference to engage in energetic, action oriented activities. Intake refers to the ability of some people to concentrate on a task while eating, drinking, chewing, smoking or biting. For some learners it is impossible to concentrate while performing any of these activities. The time of the day or the night influences learners differently. Many learners prefer to work during the early hours in the morning while others prefer to work during the evening hours, etc. The last two elements within the physical category are mobility vs. passivity. Sitting for long periods constitute a problem for many learners unless they are interested in what they are learning; for others even short periods make them feel uncomfortable. Preference in this category varies from student to student.

Finally, the fifth category of learning styles includes the

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[38] Ibid., p. 498.

psychological elements. Global vs. analytic type of learning are characterized by different behaviors. Analytic learners learn sequentially, step by step, in a well ordered continuum, the way mathematics, biology, and grammar are taught. Global learners cannot begin to focus on the content without an initial overall gestalt of the meaning and use of what will be taught. Such students require a visual image of the topic and an illustrative anecdote to involve their thinking and motivation. The brain's hemispheric preference is another element within the psychological elements. Right-hemispheric learners are generally characterized as possessing the following: a) are less bothered by sound when studying, b) prefer dim illumination, c) require an informal design, d) are less motivated in school, e) are less persistant, f) prefer learning with peers, and g) prefer tactile to auditory or visual stimulation.[39] Finally, the third element within the psychological dimension of learning style is impulsivity vs. reflectivity. Impulsive students often call out answers without considering varying possibilities, while reflectives rarely volunteer information although they may know the answers. Verbal class participation is difficult for some and easy for others who are referred to a "reflectives".

Barbara Fisher and Louis Fisher use the term style as referring to "a pervasive quality in the behavior of an individual, a quality that persists though the content may change."[40] Based on direct

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[39] Ibid., p. 500.

[40] Barbara B. Fisher and Louis Fisher, "Styles of Teaching and Learning," Educational Leadership (January, 1979), p. 245.

observation, experience and discussion with teachers, Fisher and Fisher identify ten learning styles and six teaching styles. The ten learning styles can be summarized as follows:

1. The incremental learner - This student proceeds in step by step position, systematically adding bits and pieces together to gain larger understanding.

2. The intuitive learner - These students are characterized by leaps in various directions, sudden insights and meaningful and accurate generalizations.

3. The sensory specialist - These students rely primarily on one sense for the meaningful formation of ideas.

4. The sensory generalist - These students use all or many of the senses in gathering information and gaining insights.

5. The emotionally involved - These are students who function best in a classroom in which the atmosphere carries a high emotional charge.

6. The emotionally neutral - These students function best when the emotional tone is low-keyed and relatively neutral.

7. Explicitly structured - These students learn best when the teacher makes explicit a clear, unambiguous structure for learning.

8. Open-ended structure - These students learn best in a fairly open-ended learning environment.

9. The damaged learner - These are students who are physically normal yet damaged in self concept, social competency, aesthetic sensitivity or intellect.

10. The eclectic learner - These are learners who can shift and

adapt to and benefit from different learning styles.[41]

Further, Fisher and Fisher identify six styles of teaching that can be summarized as follows:

1. The task oriented teacher - These teachers demand specific performance on the part of the student.

2. The cooperative planner - These teachers plan the means and ends of instruction with students' cooperation.

3. The child centered - These teachers provide a structure for students to pursue whatever they want to do or whatever interests them.

4. The subject centered - These teachers focus on organized content to the near exclusion of the learner.

5. The learning centered - These teachers have equal concern for the students, for the curricular objectives and for the materials to be learned.

6. The emotionally exciting and its counterpart - These teachers show their own intensive emotional involvement in teaching; their counterpart conducts classrooms subdued in emotional tone.[42]

Fisher and Fisher add a new dimension to the concept of learning styles for they see student's learning not only as a function of the student's learning style, but as a function of the teaching style. Different instructional problems arise and different outcomes are

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[41]Ibid., pp. 246, 249.

[42]Ibid., p. 251.

achieved depending on the combinations found in various classrooms.[43] For instance, the incremental learner who functions most effectively in an explicitly structured classroom will function quite differently with a teacher who has a subject-centered, task oriented style than will a classmate whose style may be intuitive and favoring a more open structure.[44] This example suggests that the matching or mismatching of the student's learning style with the teaching style will result in different outcomes in student's learning, so the consideration of both is essential to the instructional process.

Carl Jung's Theory of Psychological Types

Carl Jung's theory of psychological types provides the best means for drawing the diverse research of learning style into one conceptual scheme.[45] In Jung's theory, all conscious, mental activity can be classified into four processes - two perception processes: sensing and intuition; and two judgment processes: thinking and feeling. What comes into consciousness comes either through the senses or through intuition. Perceptions must be used to remain in consciousness. They are used, sorted, weighed, analyzed, evaluated, assigned into action, etc., by the two judgment processes, thinking and feeling.[46]

Everyone regularly uses all four processes, but need not use them

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[43] Ibid., p. 251.

[44] Ibid., p. 251.

[45] Gordon Lawrence, "Personality Structure and Learning Style: Uses of the Myers Briggs Type Indicator," Student Learning Styles and Brain Behavior (Preston, Virginia, 1982), p. 92.

[46] Ibid., p. 93.

equally well. From childhood each of us has come to rely on one condition in human experience. In the instant that conscious attention is focused on sensing, it cannot also be focused on intuition and vice versa. One may shift quickly from one to the other, but cannot attend to both at once.[47]

To avoid one-dimensional personality, a person must develop a helping or auxiliary process to balance the dominant process. Because of the polarity concept just described, the auxiliary is always formed in the dimension other than the dominant one. A person having sensing or intuition as the dominant process, for example, will develop either thinking or feeling as the auxiliary process. Thus, combining dominant and auxiliary processes eight sets are formed:

Dominant auxiliary	Dominant auxiliary
sensing with thinking	intuition with thinking
sensing with feeling	intuition with feeling
thinking with sensing	thinking with intuition
feeling with sensing	feeling with intuition[48]

The sensing with thinking people focus their practical outlook on the aspects of the world that are readily subject to logical analysis - the objects, machinery, and the more impersonal transactions of life. In contrast, the sensing with feeling people attend primarily to the practical side of human needs. Still different in emphasis, the thinking-with-sensing people are those who wish to superimpose their system of logical order on the practical matters of the world.

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[47]Ibid., p. 93.

[48]Ibid., p. 94.

And the feeling with sensing people are concerned primarily with harmonious relationships and seem to attain them through practical helpfulness. The differences suggested here are subtle, but not superficial.[49] The intuition with thinking people, for example, may often test their intuitive inspirations with logical analysis and the analysis may fault the inspiration. If the inspiration is compelling enough, however, no amount of logic will override the intuition. In a showdown, intuition will always prevail because it is the dominant process in these people. In contrast, the thinking-with-intuition person would always sacrifice the intuition in such a showdown.[50]

Jung makes a clear distinction between extrovert people and introvert people. Simply put, extroverts will say: "When in doubt, reflect on the matter more deeply."[51] Extroverts, by definition, reveal their best first. What you see is what you get. Introverts, reserving their best for the inner world, their favored world, reveal mainly their auxiliary process to others. Only close associates will be allowed to see the most valued process in operation. Introvert thinkers want to exercise their dominant process (thinking) mainly in the inner realm of private mental activity. They strive, above all else, to have orderly, logical minds.[52] They use their auxiliary process, intuition mainly, to run their outer lives, and give the

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[49]Ibid., p. 94.

[50]Ibid., p. 95.

[51]Ibid., p. 95.

[52]Ibid., p. 95.

appearance of being intuitive dominants.[53]

In Jung´s theory, the attitude taken toward the outer world is called the fourth dimension.[54] In this personality pattern the drive is always toward closure, toward having a settled system in a place; the drive is toward keeping plans and organization to a necessary minimum so that one can respond to new perceptions and adapt flexibly to new circumstances.

The most essential relationship between type and learning style can be seen in the nature of the dominant mental process in each personality. In Jung´s theory of psychological types all conscious mental activity occurs in two perception processes (thinking and feeling) and in two processes (thinking and feeling). This leads to the four dimensions of type theory: extraversion-intraversion, sensing intuition, thinking feeling and perception.[55] The thinking dominant type in a school setting is energized by logically organized material. They thrive on things that can be analyzed and resent what must be learned if it doesn´t fit logically into their mental systems. They respond best to the teacher who is well organized and resist and resent the teacher whose organization is not logical. If they do not find logical orderliness in either the material or the teacher, they cannot bring their best energies and effort to the learning task.[56]

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[53]Ibid., p. 96.

[54]Ibid., p. 96.

[55]Ibid., p. 97.

[56]Ibid., p. 98.

Children who are essentially the sensing types may appreciate logical order and harmonious working relationships but their learning motivation does not depend primarily on either. Above all else, they respond to what they see as practical and functional. Their criteria are: Can this teacher and this material show me something useful, skills that my senses can master and put to good use?[57] These students are more likely to become lost when the teacher skips steps in explanations and directions, leaves large gaps for students imagination to close, teaches abstractions without checking to see whether they connect with concrete realities in the student's world, and teaches facts and skills that can only be put to real use at some indeterminate time in the future. Sensing types do their best mental work when their senses are most fully engaged.[58]

The final group, the intuitive dominants, crave inspiration above all else. They are fully engaged only when their imaginations are fired with intriguing ideas and plans. For them, routine quickly becomes dull. Unless the teacher or the material inspires them, boredom drives them to seek out something else, anything to reestablish the inspirational charge. Often, they resort to daydreaming, reading off-task material, or undermining the teacher. Their energy flows to wherever the inspiration is. When inspired, they are the most innovative of all types.[59]

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[57]Ibid., p. 99.

[58]Ibid., p. 91.

[59]Ibid., p. 99.

Research Findings in Learning Styles

The following section will review some of the most recent research findings related to learning styles. Different research studies at the elementary, secondary and college level provide evidence about student academic achievement improvement when their learning styles are taken into consideration.

Lynch[60] conducted a study of 136 high school students. He found that, when matched with their time-of-day preference and mismatched for teacher assignment, chronic truants attended school more frequently (3.5 units per 10 week marking period). A significant interaction (at the .01 level) occurred among degree of truancy, learning style preference, and English teacher assignment, suggesting that time preference was a crucial factor in the reversal of truancy patterns. Had the students not accurately identified their time preference, statistically significant interactions could not have occurred.

Shea[61] conducted another study of 32 ninth graders. He found

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[60]P.K. Lynch, "An Analysis of the Relationships Among Academic Achievement, Attendance and the Individual Learning Style Time Preferences of Eleventh and Twelfth Grade Students Identified as Initial or Chronic Truants in a Suburban New York District." Quoted in Rita Dunn, "Learning Style and its Relation to Exceptionality at Both Ends of the Spectrum," Learning Style Network (Jamaica, New York: School of Education and Human Services, St. John University, March, 1984), p. 10.

[61]T.C. Shea, "An Investigation of the Relationship Among Preferences for the Learning Style Element of Design, Selected Instructional Environments, and Reading Achievement in Ninth Grade Students to Improve Administrative Determinants Concerning Effective Educational Facilities." Quoted in Rita Dunn, Ibid., p. 10.

that when students were matched with their learning style preference for design (formal vs. informal organization of the classroom), statistically significantly higher reading scores resulted at the .01 level. Students who were mismatched for informal design achieved statistically significantly lower than when matched.

Douglas[62] experimenting with high school students found that deductive students taught through deductive biology materials and inductive students taught through inductive materials each achieved better than when taught in mismatched situations.

Tannenbaum[63] found that field independent students of tenth, eleventh, and twelfth grade, provided low structure, and field dependent students, provided high structure, performed statistically significantly better when taught through complementary-matched methods.

Trautman's[64] study of junior high school students showed that when the instructional materials were matched correctly with the students identified style, statistically significant academic gains were made; wherever the materials and styles were mismatched,

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[62] C.B. Douglas, "Making Biology Easy to Understand." Quoted in Rita Dunn, Ibid., p. 11.

[63] R. Tannenbaum, "An Investigation of the Relationship Between Selected Instructional Techniques and Identified Field Dependent and Field Independent Cognitive Styles as Evidenced Among High School Students Enrolled in Studies of Nutrition." Quoted in Rita Dunn, Ibid., p. 11.

[64] P. Trautman, "An Investigation of the Relationship Between Selected Instructional Techniques and Identified Cognitive Style." Wuoted in Rita Dunn, Ibid., p. 11.

achievement fell below that of both matched groups. It was also found that there is no difference between the relative achievement of analytic and global students when they are taught through materials that match their styles

Other studies have been conducted at the elementary level that show academic improvement when students are matched with their learning style. Pizzo[65] studied 64 sixth graders and found that when students were matched with their learning style preferences, statistically significantly higher reading and attitude scores resulted at the .01 level. Students who were mismatched achieved statistically significantly below the matched students. Krimsky[66] studied 32 fourth graders and found that students who preferred bright light performed statistically significantly better when tested in bright lit areas; those who preferred reading in dim light did equally as well in a low-light setting. Both groups performed statistically less well when tested in mismatched situations.

Several studies have been conducted at the college level. Farr[67] found that college students accurately predicted the modality in which

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[65] J. Pizzo, "An Investigation of the Relationships Between Selected Acoustic Environments and Sound, an Element of Learning Style, as They Affect Sixth Grade Students Reading Achievement and Attitudes." Quoted in Rita Dunn, Ibid., p. 11.

[66] J.S. Krimsky, "A Comparative Analysis of the Effects of Matching and Mismatching Fourth Grade Students With Their Learning Style Preferences for the Enviromental Element of Light and Their Subsequent Reading Speed and Accuracy Scores." Quoted in Rita Dunn, Ibid., p. 11.

[67] B.J. Farr, "Individual Differences in Learning: Predicting One's More Effective Learning Modality." Quoted in Rita Dunn, Ibid., p. 10.

they would achieve superior academic performance. It was advantageous to learn and be tested in the preferred modality. However, this advantage was reduced when learning and testing were both in the non-preferred modality. Domino[68] in a study of 100 college students found that students taught in preferred styles scored higher on tests, fact, knowledge, attitude, and efficiency than those taught in a manner dissonant from their orientation.

White[69] conducted a study of seventh and eighth graders. He found that persistent and responsible students achieved statistically significantly higher than students with low persistence and responsibility scores. Students identified as being persistent and responsible also were identified as manifesting conforming behavior. The findings of this study also show that less persistent and less responsible students do not learn through conformity.

Several studies have been conducted in relation to learning styles of gifted/talented students. Griggs and Price,[70] using the Learning Style Inventory (Dunn, R; Dunn, K & Price) with seventh, eighth and ninth graders found that gifted students are persistent,

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[68] G. Domino, "Interactive Effects of Achievement Orientation and Teaching Style on Academic Achievement." Quoted in Rita Dunn, Ibid., p. 10.

[69] R.T. White, "An Investigation of the Relationship Between Selected Instructional Methods and Selected Elements of Emotional Learning Style Upon Student Achievement in Seventh Grade Social Studies." Quoted in Rita Dunn, Ibid., p. 10.

[70] S. Griggs and G. Price, "A Comparison Between the Learning Styles of Gifted Versus Average Suburban Junior High School Students." Quoted in Rita Dunn, Ibid., p. 12.

self-motivated, perceptually strong, and prefer working alone with no lectures. The same findings were revealed by Kreitner[71] in a study of seventh to twelfth graders. Price, Dunn, Dunn, and Griggs[72] found that gifted students are self-motivated, persistent, perceptually strong, and non-conforming. The study showed that the gifted students also prefer options, formal design, no lectures, and prefer learning alone.

During the last decade a great number of doctoral dissertations have been conducted on the subject of learning styles. Some of these and their most important findings are mentioned in the following paragraphs:

Bogue[73] studied more than 100 college students to determine whether a relationship existed between the cognitive dimensions of field dependency, level of imagery, verbal ability, word versus shape sorting preferences, and achievement from pictorial or verbal presentations. The following conclusions were drawn: (1) Holistic students learned details best from pictures; those with linear cognitive styles achieved more from verbal presentations; (2) When drawing inferences, linear processors evidenced greater achievement

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[71] K.K. Kreitner, "Modality Strengths and Learning Styles of Musically Talented High School Students." Quoted in Rita Dunn, Ibid., p. 12.

[72] Dunn, Dunn and Griggs, "Studies in Students Learning Styles." Quoted in Rita Dunn, Ibid., p. 12.

[73] S.D. Bogue, "Differential Learning for Verbal and Pictorial Presentations." Quoted in Learning Style Network, Annotated Bibliography: 1984, p. 4.

regardless of the form of the presentation; (3) High imagers benefited more from the verbal presentation, while low imagers' achievement favored the visual.

Burton[74] identified field independent and field dependent kindergarteners and exposed them to words that were both essentially similar and maximally different in type. Although field independents learned more words than field dependents, both groups mastered more words that were visually different from each other than words that were similar, despite their teacher's semester-long emphasis on a phonics approach to reading.

Cafferty[75] studied the learning styles of all teachers and all sophomores and juniors in a selected high school. They were identified and either matched or mismatched. Sixteen hundred and eighty-nine teacher-student pairs were confirmed. Students then were grouped based on the degree to which their styles matched their teachers'. The overall findings demonstrated that the greater the degree of congruence between the teacher's and student's style, the higher the Grade Point Average. Conversely, the greater the dissonance between the two, the lower the Grade Point Average.

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[74]Elizabeth Burton, "An Analysis of the Interactions of Field Independence/Dependence and Word Type as They Affect Word Recognition Among Kindergarteners." Quoted in Ibid., p. 5.

[75]E. Cafferty, "An Analysis of Student Performance Based Upon the Degree of Match Between the Educational Cognitive Style of the Teacher and the Educational Cognitive Style of the Student." Quoted in Ibid., p. 6.

Copenhaver's[76] research revealed that students' learning styles were consistent across subject areas, but were somewhat inconsistent across time. In both English and mathematics classes, students tended to prefer the same learning approaches, but, over a period of time, individual learning styles changed somewhat.

Valle[77] conducted an experimental investigation of the relationship(s) between preference for mobility (freedom to move through scheduled periods) and the word recognition scores of seventh grade students. The purpose of the study was to provide supervisory and administrative guidelines for the organization of effective instructional environments. Analysis of the relationship among the need to move while learning, the environment in which instruction occurs, and the effect of both on word-pair recognition scores revealed that when secondary students were placed into settings congruent with their diagnosed learning style preferences for mobility versus passivity, achievement scores increased beyond the statistically significant .001 level.

Harty[78] studied 25 students in a small Ohio high school Level II

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[76] R.W. Copenhaver, "The Consistency of Student Learning Styles as They Move from English to Mathematics." Quoted in Ibid., p. 9.

[77] J.D. Valle, "An Experimental Investigation of the Relationships Between Preference for Mobility and the Word Recognition Scores of Seventh Grade Students to Provide Supervisory and Administrative Guidelines for the Organization of Effective Instructional Environments." Quoted in Ibid., p. 11.

[78] P.M. Harty, "Learning Style: A Matter of Difference in the Foreign Language Classroom." Quoted in Ibid., p. 28.

Spanish course. They were tested for their learning styles and then taught in ways that complemented their unique characteristics during the 1981-82 school year. When comparing each student's baseline data to the scores obtained during the experimental period, 64 percent evidenced statistically significant academic increases, one student maintained the A average previously obtained, and 32 percent did not achieve as well, but evidenced a need for stability of instructional method rather than a need for variety. The latter group may react negatively to change of any kind. The majority of students reported improved attitudes toward learning and simultaneously demonstrated no behavior problems. Feedback from teachers not involved in the program indicated that students described the learning styles experience positively and enthusiastically based on unsolicited comments.

Kaley[79] studied field dependence/independence and learning styles in sixth graders. This study supported previous ones which revealed that selected learning styles tend to correlate with high or low reading achievement. The author found that reading achievement is a statistically stronger and more efficient predictor of learning style than is I.Q. The higher a child's reading level, the more independent is his learning style; conversely, a lower level of reading is suggestive of a more dependent approach to learning.

<u>The Brain Functioning</u>

Besides the research conducted in learning styles, other research has been developed in the area of brain hemispheres. Roger Sperry,

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[79]S.B. Kaley, "Field Dependence/Independence and Learning Styles in Sixth Graders." Quoted in Ibid., p. 31.

Torstein Wiesel and David Hubel, at the California Institute of Technology showed that when the two sides of the brain are surgically separated, they can each have separate thoughts, knowledge, and emotions. They demonstrated in "split-brain" subjects that each hemisphere is specialized in carrying out certain functions. In general, the right hemisphere is specialized for functions that deal with non-verbal processes (e.g. drawing, spatial awareness) while the left hemisphere is dominant for language.[80]

Joseph Hellige of the University of Southern California and his associates have shown that as task complexity increases, bilateral hemispheric engagement increases and performance is consequently enhanced. Even split brain patients attempt to engage both hemispheres as task complexity increases. The normal brains operate at optimal level when cognitive processing requirements are of sufficient complexity to activate both sides of the brain and provide a mutual facilitation between hemispheres as they integrate simultaneous activity.[81]

During the 1950's a neurosurgeon Wilder Penfield and his colleagues at the Montreal Neurological Institute made a startling discovery. They learned that past events in a patient's life could be mentally brought to life by an electrode applied to the temporal lobe. Patients used in this experiment frequently reported that, upon

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[80] Richard M. Restak, "The Brain," Student Learning Styles and Brain Behavior (Preston, Virginia: NASSP, 1982), p. 161.

[81] Jerry Levy, "Children Think with Whole Brain: Myth and Reality," Ibid., p. 180.

stimulation, everything around them seemed to have occurred before.[82]

In the 1940's brain researchers began cutting the corpus collosum (a track of nerve fibers, also called the cerebral commisure, connecting the two hemispheres) to prevent seizure discharges from being relayed from one hemisphere to the other. But the notion of holistic brain functioning can be traced back 120 years.[83] During the 1860's an English neurologist, John Hughlings Jackson developed the novel theory that the central nervous system has a complex "vertical" organization with many functions somehow represented at different levels starting with the lowest spinal cord level and proceeding up to the rarified realm of the cerebral cortex. Jackson's theory was based on his observation that a circumscribed injury never leads to a complete loss of function.[84] By the same time (1861) a French physician named Paul Broca published an account of a patient in the Salpetrure who had suffered a stroke years earlier. Rather than rendering him completely mute, however, the stroke had allowed the patient to speak in short, laborious, telegraphic sentences (e.g., I went restaurant food), a condition Broca called aphasia. Examination of the patient's brain after death revealed a precise area of destruction in the left cerebral hemisphere that Broca postulated was responsible for speech.[85]

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[82]Op.cit., p. 164.

[83]Ibid., p. 160.

[84]Ibid., p. 63.

[85]Ibid., p. 160.

Little data is available about hemisphere asymmetries in mathematics and logical functions although arithmetical disorders can occur with either right-side or left-side damage. The right hemisphere of split brain patients can do simple single-digit addition, substraction, and multiplication, and it surpasses the left at discriminating line orientation, other objects in space, and at discriminating the direction in which a point moves.[86] These capacities, as well as the spatial-perceptual superiorities noted earlier, are of major importance in geometric understanding which itself is necessary for a real understanding of algebraic. relationships.

Given the left hemisphere's superiority in extracting meaning from syntactical structure, it might be expected to surpass the right hemisphere in derivation of meaning from algebraic structure and manipulation, and reordering of algebraic symbols, but there is no direct evidence of this.[87] In geometric reasoning, the right hemisphere is clearly superior, greatly surpassing the left hemisphere in operations such as viewing an opened-up drawing of an unfolded shape and mentally folding the drawing into a three dimensional object. This mental manipulation of spatial relationships involves not only visualization abilities, but a rule-governed plan of transformation. An even more striking example of right hemisphere reasoning comes from split brain studies showing that the right

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[86] Jerry Levy, "Children Think with Whole Brain: Myth and Reality," p. 175.

[87] Ibid., p. 178.

hemisphere can inspect a set of geometric shapes, extract the defining characteristics property of the set, and identify the shape within the set that does not belong. The right hemisphere does this at a far better level than the left.[88]

The evidence strongly disputes the idea that students learn with only one side of the brain, but we do have evidence that there are individual differences among people to the extent that one hemisphere is more differentially aroused than the other.[89] Gur and Reivich, for example, have found that people differ in the asymmetry of blood flow to the two sides of the brain and those having an asymmetric flow in favor of the right-hemisphere perform better on perceptual completion tasks (thought to be right hemisphere specialized). Individual differences exist in the extent to which people show a biased attention to the left or right side of space.[90]

Similarly, some children may better gain mathematical understanding if they are first taught the structure of algebraic equations and the methods of symbol manipulation.[91] In the end, however, we want these children to appreciate the geometric, spatial functions specified by equations. We want them to understand why we say an equation of the form X = A + By is called linear while one of

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[87]Ibid., p. 178.

[88]Ibid., p. 181.

[90]Ibid., p. 181.

[91]Ibid., p. 181.

the form $X = A + By + Cy$ is called quadratic.[92] We want them to visualize a straight line defining the function between x and y for the linear equation, and a quadratic curve defining the function between x and y for the quadratic equation. Other children better understand if they are first taught the visual geometric relationship, but ultimately, we also want them to be able to specify these geometric forms in a symbolic equation. From this perspective, learning styles refer to the method of introducing material, not to the type of understanding we ultimately want the child to gain, nor the hemisphere we seek to educate.[93]

Models of Teaching

Models of teaching are strategies based on the theory and research of educators, psychologists, philosophers, and others who question how individuals learn.[94] Some models are designed to help students grow in self awareness or creativity, some foster the development of self descriptive or responsible participation in a group; some models stimulate inductive reasoning or theory building; and others provide for mastery of subject matter.[95]

Bruce Joyce and Marsha Weil have identified more than eighty models of teaching from which teachers can choose to match the

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[92]Ibid., p. 181.

[93]Ibid., p. 181.

[94]Susan S. Ellis, "Models of Teaching: A Solution to the Teaching Style/Learning Style Dilemma," Educational Leadership (January, 1979), p. 275.

[95]Ibid., p. 275.

peculiarities of student's learning. They define model as "... a pattern or plan which can be used to shape a curriculum or course, to select instructional materials, and to guide a teacher's actions."[96] The models will help the teacher to increase instructional effectiveness, for the teacher has a variety of choices in order to respond to the diverse demands of his/her students.

> We make the assumption that there are many kinds of learning for the most part requiring different methods of instruction. We also assume that our students come to us with different learning styles, calling for different approaches if each one is to become a productive and effective learner.[97]

Rather than suggesting the superiority of one model over the other, Joyce suggests enriching the variety of models for teaching for no single model is applicable to all students or can accomplish all purposes. Variety of ways in teaching will facilitate student's development. The existence of widely different learning styles prevents there being any possibility of any single "correct" way to teach or to learn.[98]

> The recent surge of interest in learning styles comes from a humane concern with individual differences. We can be certain that whatever teaching strategies we use at any given time, our students will not react identically.... Each time a teacher employs a new strategy of teaching the question arises similarly what do I do about the students who are made uncomfortable by the new approach?[99]

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[96]Bruce Joyce, et al., Models of Teaching (Englewood Cliffs, NJ: Prentice Hall Inc., 1972), p. 3.

[97]Ibid., p. 2.

[98]Noel Entwistle, Styles of Learning and Teaching (Chickester: 1981), p. 270.

[99]Bruce R. Joyce, "Learning How to Learn," Theory Into Practice, Vol. XIX, No. 1, p. 15.

This statement implies an endless effort from the teacher to continuously search for the strategies to better suit the student's learning characteristics and which are more appropriate to reach specific goals.

> ... no single approach to teaching is appropriate in all situations, and consequently, effective teaching requires alternative strategies to accomplish different goals.[100]

From this point of view, flexibility is a key component of the teaching process. The teacher shall be able to switch from one strategy to another in order to cope with the great variety of student learning differences and needs. In other words, the teacher shall create the environment that better matches the student's varied styles. Joyce has classified various models of teaching for creating environments and providing specifications for designing and constructing learning situations. Joyce has classified approaches of teaching into four families: the information processing models, the social interaction models, the personal models and behavior modification/cybernetic models. These families represent distinct orientations toward people and how they learn.

"The information processing refers to the way people handle stimuli from the environment, organize data, sense problems, generate concepts and solutions to problems, and employ verbal and non-verbal symbols."[101] The goals of information processing models are: the development of intellectual capabilities and the acquisition of

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[100]Paul D. Eggen, et al., Strategies for Teachers (Englewood Cliffs, NJ: Prentice Hall, Inc., 1979), p. 3.

[101]Op.cit., p. 15.

content. The intellectual skills or capabilities required to analyze information are called processes and include the ability to make observations and, through the use of inference, to generalize, to predict, and to explain events. Through these processes, the learner is able to move beyond memorization of information to the development of more abstract and useful forms of knowledge. The knowledge that results from the processing of information is called content.[102]

Observations are items of information acquired through our senses in a direct way or through the observation of others in an indirect way. Teaching students to be good observers improves the ability to gather information about their environment, which at the same time helps them to be more sensitive to it. Observations become the basic units for building increasingly complex structures of knowledge.[103] Accuracy and precision are important qualities of observations. It is more accurate to describe an object in terms of its weight in kilograms than to describe it as heavy or light.

The individual can process information into more abstract, more usable forms that go beyond immediate observations to construct patterns, to predict future observations, and to explain events. These extensions and interpretations of observations are called inferences. There are three forms of inferences: generalizing, predictive and explanatory. Generalizing inferences are statements

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[102] Op.cit., p. 15.

[103] Ibid., p. 21.

which summarize and extend a large number of discrete observations.[104] They make observations more usable and extend them to cases not yet observed.

Predictive inferences are based upon generalizing inferences. They refer to specific singular observations. Our confidence in the correctness of a predictive inference is directly related to our confidence in the generalizing inference upon which it is based, and this in turn is related to the number and consistency of the observations upon which the generalizing inference is based.[105]

Explanatory inferences are used to explain observations. So it implies an observation of an event and our interpretation of the observation. In this case the observation is linked to an inference, and the inference was used to explain the observation. As is the case of predictive inferences, explanatory inferences are based upon previously formed generalizing inferences.

The second major goal of the Information Processing Model is called content acquisition.

> Through different processes, people gather information from the world around them. This information, when stored in one's brain, becomes knowledge which can be used in future information processing attempts. When considered from a teaching perspective, this knowledge is called content. Content exists in three primary forms: facts, concepts and generalizations.[106]

Facts are the most basic type of information formed through

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[104]Ibid., p. 22.

[105]Ibid., p. 24.

[106]Ibid., p. 32.

processing of observations. Facts are said to be singular in occurrence, occurring in the past or existing in the present, and have no predictive value because they are not statements about general trends or patterns.

Concepts are defined as the form of data or form of content that results from the categorization of a number of observations.[107] Through inferential processes, facts are summarized and abstracted to form concepts. Concepts permit us to cope with overwhelming amounts of information by grouping in categories of information. In this way, we can remember categories rather than individual facts. This grouping in categories is based on the identification of similarities and differences of facts. The description of the meaning of the concept is called the definition of the concept.[108] Concepts are described or taught by their attributes or characteristics or distinctive features. In learning a concept, the student must first differentiate between the relevant and the irrelevant characteristics, and then must encode or remember the important characteristics for later use.[109]

A generalization is an inferential statement which expresses a relationship between two or more concepts, applies to more than one event and has predictive and explanatory value.[110] Generalizations

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[107] Ibid., p. 40.

[108] Ibid., p. 45.

[109] Ibid., p. 45.

[110] Ibid., p. 49.

vary in terms of the amount of information that supports or contradicts them and also vary in terms of inclusiveness, in that the amount of information they account for varies considerably. The narrower the concepts included in a generalization, the narrower the scope of the generalization. A generalization is more inclusive if the concepts involved are broader, more extensive and refer to increasingly larger segments of reality.

Joyce and Weil present two different reasoning models: the general deductive model of thinking and the general inductive model of thinking. Deductive reasoning is the type of thinking which proceeds from the general (some type of abstraction - a concept or generalization) to the specific (the particular conclusion reached). The major premise in a deductive sequence is either a concept definition or generalization. The minor premise is a fact or observation. The conclusion is either an explanatory or predictive inference. From this, we see that forming explanatory and predictive inferences involves deductive reasoning and the inference or conclusion is valid only to the extent that the generalization or major premise is valid.[111]

The general deductive model of teaching begins by a concept definition or generalization which is then followed by illustrative examples of the abstraction.[112] This step is followed by

[111]Ibid., p. 107.

[112]Ibid., p. 107.

clarification of terms to make sure such terms are familiar to the students. Then the teacher classifies some examples and explains the basis for the classification. Then the teacher asks the students to categorize additional examples as either positive or negative examples, and to explain the basis for their classification. Finally, students are asked to generate their own examples. The selection of goals and the appropriate selection of the examples in accord with the characteristics of the concept or generalization being taught are very important in this model.

Inductive reasoning is the type of thinking which proceeds from the specific to the general. Observations are processed into a concept or generalization. The individual arrives to the knowledge of the abstraction after observing and analyzing the observations.

The general inductive model is a teaching strategy which uses data to teach concepts and generalizations.[113] In this model the teacher presents students with data, asks students to make observations of the data, and on the basis of these observations, to form the abstraction being taught.[114] This model is very effective in teaching concepts and generalizations and very good in motivating students. It also promotes students active participation. It helps teachers to integrate affective and cognitive goals. An inductive activity is effective in developing perceptual and observational skills in young students and inferential skills in both young and

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[113]Ibid., p. 115.

[114]Ibid., p. 116.

older students.[115]

The selection of examples is fundamental in planning inductive activities, for the examples provide the data from the abstractions. The information needed to form the concepts should be observable in the examples. Examples with observable characteristics minimize the effect of prior knowledge and emphasize the importance of observational skills in the activity. The second step in implementing the inductive model is the presentation of illustrations in which students make as many observations as possible. This step continues until the students acquire the abstraction. The third phase, closure, brings the lesson to form a conclusion and makes students have a clear picture of what has been taught. Finally, additional examples are provided to reinforce the concept, to test students understanding of the concept, and to provide the teacher with some kind of measure of students' understanding of the abstraction.

Joyce and Weil developed four concepts for describing the operations of the model (syntax, social system, principles of reaction and support system). The syntax describes the model in action: what kind of activities to be used, how to begin and which are the subsequent steps. The social system describes students and teacher roles and relationships and the kind of norms that are encouraged. This system becomes less structured as roles, relationships, norms, and activities are under students' control. The principles of reaction refer to how the teacher should regard the learner and how to

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[115]Ibid., p. 116.

Table 1

Social-Interaction Models--A Selection[116]

Model	Major Theorist	Missions or Goals For Which Intended
Group Investigation	Herbert Thelen John Dewey	Development of skills for participation in democratic social process through combined emphasis on interpersonal (group) skills and academic inquiry skills. Aspects of personal development are important outgrowths of this model.
Social Inquiry	Byron Massialas Benjamin Cox	Social problem-solving, primarily through academic inquiry and logical reasoning.
Laboratory Method	National Training Laboratory (NTL) Bethel, Maine	Development of interpersonal and group skills and, through this, personal awareness and flexibility.
Jurisprudential	Donald Oliver James P. Shaver	Designed primarily to teach the jurisprudential frame of reference as a way of thinking about and resolving social issues.
Role Playing	Fannie Shaftel George Shaftel	Designed to induce students to inquire into personal and social values, with their own behavior and values becoming the source of their inquiry.
Social Simulation	Sarene Boocock	Designed to help students experience various social processes and realities and to examine their own reactions to them.

The social-interaction models stress the relationship of the individuals to society or to other persons. They are also concerned with the development of the mind and the self, and the learning of academic subjects.

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[116]Bruce R. Joyce, "Learning How to Learn," Theory Into Practice, Vol. XIX, No. 1, p. 16.

Table 2

Information-Processing Models--A Selection[117]

Model	Major Theorist	Missions or Goals For Which Intended
Inductive Thinking Inquiry Training Model	Hilda Taba Richard Suchman	Designed primarily for development of inductive mental processes and academic reasoning or theory building, but these capacities are useful for personal and social goals as well.
Scientific Inquiry	Joseph J. Schwab (also much of the Curriculum Reform Movement of the 1960s)	Designed to teach the research system of a discipline, but also expected to have effects in other domains (sociological methods may be taught in order to increase social understanding and social problem-solving).
Concept Attainment	Jerome Bruner	Designed primarily to develop inductive reasoning, but also for concept development and analysis.
Cognitive Growth	Jean Piaget Irving Siegel Edmund Sullivan	Designed to increase general intellectual development, especially logical reasoning, but can be applied to social and moral development as well (see Kohlberg, 1966).
Advance Organizer Model	David Ausubel	Designed to increase the efficiency of information processing capacities to meaningfully absorb and relate bodies of knowledge.
Memory	Jerry Lucas	Designed to increase capacity to memorize.

[117]Ibid., p. 16.

Table 3

Personal Models--A Selection[118]

Model	Major Theorist	Missions or Goals For Which Intended
Nondirective Teaching	Carl Rogers	Emphasis on building the capacity for personal development in terms of self-awareness, understanding, autonomy, and self-concept.
Awareness Training	Fritz Perls William Schutz	Increasing one's capacity for self-exploration and self-awareness. Much emphasis on development of interpersonal awareness and understanding, as well as body and sensory awareness.
Synectics	William Gordon	Personal development of creativity and creative problem-solving.
Conceptual Systems	David Hunt	Designed to increase personal complexity and flexibility.
Classroom Meeting (Social Problem-Solving)	William Glasser	Development of self-understanding and responsibility to oneself and one's social group.

The personal model is oriented toward the individual and the development of self-kind. It focuses its attention to emotional life, helping individuals to develop a productive relationship with their environments and to view themselves as capable persons.

118Ibid., p. 17.

Table 4

Behavior Modification/Cybernetic Models--A Selection[119]

Model	Major Theorist	Mission or Goals For Which Intended
Programmed Instruction	B.F. Skinner	Facts, concepts, skills
Managing Behavior	B.F. Skinner	Social behavior/skills
Relaxation	Rinn, Wolpe	Personal goals (for example, reduction of stress, anxiety)
Anxiety Reduction	Rinn, Wolpe	Substitution of relaxation for anxiety in social situations.
Assertive Training	Wolpe	Expression of feelings in social situation.
Simulation	Link, Guetzkow Glasser	Concepts and decision-making skills
Direct Training	Lumsdaine	Pattern of behavior, skills

The behavior modification models emphasize on changing the visible behavior of the learner. They are based on principles of stimulus, control and reinforcement.

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[119]Ibid., p. 18.

respond to the learner's behavior. The support system refers to the supporting conditions necessary for the existence of the model. It refers to the other requirements beyond human skills, capacities and technical facilities. Finally, the instructional and nurturant effects of the model refer to the indirect effect that comes from experiencing the environment created by the model. We may choose one model over the other because its nurturant or indirect effects further other goals or because they reinforce the direct instructional effects.

Summary

The issues and problems surrounding mathematics education arise from the particular assumptions about the nature of mathematics and from forces from within and outside the school. Some of those issues and problems of mathematics teaching reflect the issues and problems of the society at large. To the extent that the mathematics teaching and learning is improved, the more the society will benefit from that input. One issue related to mathematics education is the danger of emphasizing the fact that mathematics consist of answers to problems. On the other hand, there is a danger of emphasizing the fact that mathematics consists of a collection of abstract structures. These two different perspectives require mixed teaching

Different approaches and methods have emerged in one effort to respond to the individuality of student's learning and the mixed ability teaching. A central issue to the teaching of mathematics is the formation of concepts. One of the greatest problems in the teaching and learning of mathematics is the formation of conceptual structures. But to make concepts fully operational, the teacher should present students with a variety of situations that exemplifies the concept.

The attitude toward the subject is an important variable of study in the teaching of mathematics. Attitude refers to a pre-disposition to react positively or negatively toward the subject of mathematics or toward any mathematics object or task. The attitudes are seen as a function of the kind of satisfaction that students derive from his mathematical experience. To the extent to which the mathematics subject is challenging enough to arouse the student's interest and active participation without being threatening, the more effective mathematics learning will be and the more positive attitude toward the subject developed.

Mathematics instruction acquires a special meaning within the bilingual context. Three variables play an important role in teaching bilingual mathematics: the language of instruction, the inclusion of appropriate cultural referents, and the attention to the cognitive styles of the children involved. Although mathematics is claimed to be meaningful to the students, the teaching strategies employed by the teacher take place in a cultural content, but cultural does not influence the method. Messick defines cognitive style as conceptualized stable attitudes, preferences, or habitual strategies determining a person's typical modes of perceiving, remembering, thinking, and problem solving. A cognitive style dimension called field independence/dependence was developed by Witkins et al.

Different educators study the concept of learning styles from different perspectives. David Kolb developed a theory of experiential learning conceived as a four stage cycle: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. These four learning modes are combined to form four learning types: Converger, Diverger, Assimilator, and Accommodator.

Anthony F. Gregorc studies the concept of learning style from a phenomenological point of view. He attributes a special meaning to the term individual, whose meaning is comprised in two parts: indi (non-divisible) and dual (duality). Gregorc argues that people function in sets of inseparable dualities which join to form four different learning preference patterns or modes: Concrete Sequential, Abstract Random, Abstract Sequential, and Concrete Random.

Rita Dunn and Kenneth Dunn identify twenty-one elements of learning styles which are classified in five broad categories: environmental (sound, light, temperature, design), emotional (motivation, persistence, responsibility, structure), sociological (peers, self, pair, team, adult, varied), physical (percpetual, intake, time, mobility), and psychological (analytic vs global, cerebral dominance, impulsive-reflective). Barbara Fisher and Louis Fisher identify ten learning styles: the incremental learner, the intuitive learner, the sensory specialist, the sensory generalist, the emotionally involved, the emotionally neutral, the explicitly structured, the open-ended structure, the damaged learner, and the eclectic learner.

Carl Jung's theory of psychological types provides a conceptual scheme for drawing the diverse research of learning style. In Jung's theory, all conscious, mental activity can be classified into four processes - two perception processes: sensing and intuition; and two judgment processes: thinking and feeling. People tend to emphasize one of these four processes. Sensing and intuition as well as thinking and feeling are polar opposites of each other. People develop a dominant process and an auxiliary process to balance that dominant process, and they are combined to form eight different proceses.

The fact that student´s academic achievement is improved when the students´ learning styles are matched with the teaching strategies is well documented by the research review for this study. The studies have been conducted, especially during the last decade at the elementary, secondary, and college level which provide evidence that support the relationship between the teaching strategies and the students´ learning styles.

Other research has been conducted in the area of brain hemisphere which suggest that the two sides of the brain perform differentiated functions and that both sides participate in the educational process. Roger Sperry, Torstein Wiesel, and David Hubel at the California Institute of Technology showed that when the two sides of the brain are surgically separated, they can each have separate thoughts, knowledge, and emotions. The evidence suggests that the right hemisphere plays a special role in emotions and in general, activation and arousal functions. The evidence also shows that the right hemisphere of split brain patients can do single digit addition, subtraction, and multiplication, and it surpasses the left at discriminating line orientation of other objects in space and at discriminating the direction in which a point moves. The right hemisphere performs better than the left side hemisphere in inspecting geometric shapes, extracting the defining characteristic properties of the set, and identifying the shape within the set that does not belong.

Bruce Joyce and Marsha Weil define a model as a pattern or plan which can be used to shape a curriculum or course, to select instructional materials and to guide a teacher's action. Joyce and Weil argue that no single model is applicable to all students or can accomplish all purposes. They have classified the teaching models in four families: the information processing models, the social interaction models, the personal models, and behavior modification models. The goals of the information processing model are the development of intellectual capabilities and the acquisition of content.

Two different reasoning models are the general deductive model and the general inductive model. The first model proceeds from the general to the specific; the second model proceeds from the specific to the general.

CHAPTER III

METHODOLOGY

Subjects

The subjects who participated in this study consisted of 93 full-time high school bilingual mathematics students enrolled in the bilingual program of Kelvyn Park High School during the academic year of 1984-1985. The participants were enrolled in mathematics classes and fell within levels 1, 2 or 3 of proficiency in the use of the English language as assessed by the Chicago Board of Education. Subjects are classified in these three levels of transition according to their proficiency in the English language. Level 1 represents the most basic category which includes students who do not know English or that are unable to communicate in the English language. The second level includes students who can communicate with difficulty in English. This is a more advanced level than level 1, but students cannot clearly communicate in the English language. Students in level 3 should be able to communicate even with difficulty, but they should be able to work with sentence structure although not able to handle complicated English. In general, students who are beyond level 3 of proficiency in the English language are able to study in the regular program. The subjects had to attend a minimum of 80% of the total number of classes during the implementation of the instructional units. All subjects of this experiment were Spanish-speaking students

*no students were deleted due to attendance criterion.

(dominant language) from Puerto Rico, Mexico, Guatemala, El Salvador, and other Spanish-speaking countries from Central and South America. The subjects under study remained in their Algebra and Pre-Algebra classes as grouped by the school adminstration. The classification according to the students' learning styles were made by the researcher within each of the four groups under study.

The population of this study was chosen from Kelvyn Park High School for there was an appropriate concentration of bilingual population that facilitated the control and manipulation of the subjects required by the research design.

Instrumentation

The relevant data regarding the individual student's learning style was collected by means of Gregorc Style Delineator (GSD) (Appendix C). GSD is a self-description test developed by Anthony Gregorc based on the phenomenology and psychological forces combined with the theory and research styles. Four constructs are identifiable in the Style Delineator: Concrete Sequential (CS), Abstract Sequential (ASO, Abstract Random (AR), and Concrete Random (CR). The Style Delineator describes the degree to which an individual sees himself or herself in relationship to each of these four constructs. When an individual is high on a particular construct, the theory of the Style Delineator suggests that specific characteristics can be attributed to that individual. The instrument was designed to elicit the individual's perceptions about his/her behavior in general and his/her learning style in particular.

The Delineator asks the subject to rank four words in a 4, 3, 2, 1 pattern. The four words are in a horizontal row and each word is part of a vertical column of ten words which represents a particular mediation channel: Concrete Sequential, Abstract Sequential, Abstract Random, and Concrete Random.

The Style Profile (Appendix D) for graphing the matrix scores for the Delineator was designed to illustrate the polar opposite of Concrete Sequential/Abstract Random, and Concrete Random/Abstract Sequential. By circling the students´ raw scores of the four vertical columns and connecting them with straight lines, it creates a graphic representation of the student´s learning style profile. The instrument seeks to elicit the individual´s natural responses to the impact of a word, not necessarily the most appropriate, or right word. The initial determination of bias or non-random occurrence of scores of the domain samples was determined by dividing the scoring continuum into high-third, middle-third and low-third, and in which the high groups can be determined by the highest 27 percentiles and lowest 27 percentiles of the measurements and other qualifications of a variable. The scoring change is as follows:

High "pointy head" - 27-40 points

Intermediate "moderate" - 16-26 points

Low "stubby point" - 10-15 points

The internal consistency of the domains represented in the operational definitions of the four domains was calculated by standardized alpha coefficients using raw data. The standardized alpha range from 0.89 for the Abstract Sequential category to .93 for the Abstract Random category.[1] The internal consistency, ranging from moderate to strong represents the most commonly accepted form of reliability reporting.

As a further indication of reliability, the GSD was given on one occasion and then given again at various intervals. The correlation coefficients between the two administrations range from 0.85 for the Concrete Sequential category to 0.88 for the Abstract Random category. The abstract sequential and the concrete random categories obtained a correlation coefficient of .87 at the .001 level.[2] This represents a strong degree of reliability as it is characterized by stability or repeatability.

The Style Delineator theoretically predicts that certain characteristics will be present in individuals classified by the instrument. The validity test showed that the GSD scores co-relates with self-rating attributes presented in random order in the range of $r = .55$ ($N = 110$) for Concrete Random category to $r = .76$ ($N = 110$) for the Abstract Sequential category.[3]

An achievement test was made by the researcher to measure the dependent variables used in the hypotheses. The test was analyzed, criticized and evaluated by a group of five mathematic teachers with a range of 10 to 20 years of experience and three curriculum specialists

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[1] Anthony F. Gregorc, Gregorce Style Delineator: Development, Technical and Administration Manual (Maynard, Massachusetts: Gabriel Systems, Inc., 1982), p. 19.

[2] Ibid., p. 19.

[3] Ibid., p. 26.

to determine whether or not the test questions were the most appropriate to measure content acquisition and the development of intellectual capabilities as defined for the purpose of this study. Seven out of the eight educational specialists (87.5%) agreed that 26 out of the 28 questions of the test (92.2%) actually measured what they were intended to measure. Based on their recommendation the remaining questions were reviewed and changed until unanimous decision was reached. In effect, the team of reviewers established the validity for the instrument.

The test was administered to 80 students from another school with similar characteristics to the experimental group. The internal consistency of the test was calculated by using the standardized alpha coefficient. The statistical analysis revealed a coefficient of .81 for the content acquisition and .83 for the intellectual capabilities category. The overall instrument reliability was .825.

In addition, the test-retest reliability was determined by the correlation coefficient between the test given at one period in time and a second administration of the same test given eight weeks later. The correlation coefficient between the two administrations was .826. This correlation represents a strong degree of reliability for the measure.

The attitudes toward the subject was measured by an Attitude Inventory (Appendix B) used by the Board of Education of the City of Chicago. The inventory was administered in a pre-test, post-test format. The test consists of 15 items. Students indicated their attitudes by selecting those statements of the inventory most similar to theirs. An average atttitude score was computed for each student. This average score was determined separately for the student's pre-test reponses and his post-test responses, thus enabling the researcher to make a comparison. Each item in the attitude survey is assigned a scale value ranging from 1.0 to 10.5. The more positive the attitude statement the greater is its corresponding scale value. To obtain the average attitude score for each student, all items checked by each student were assigned their scale values and a numerical average computed. For example, if a student checked items 1, 3, 4, 9 and 14 on his pre-test attitude survey, the sum of the scale values for these six items is 18.5 and their average was 3.08. If this student checked items 2, 5, 10, 12 and 14 on the post-test survey, the sum of the scale values for these five items is 39.0 and their average was 7.80. Since the average score increased 3.08 to 7.80 we may assume a positive attitude has been developed.

Since the Attitude Inventory is in English, it was translated to Spanish by the researcher and a group of fluent English and Spanish-speaking (bilingual) educators.

A group of teachers, counselors, coordinators and administrators were consulted by the researcher as to whether the items of the test were the most appropriate to measure the attitudes toward the math subject. This group of experts determined the construct validity of the test by an analysis of the items in relation to the attitudes that were expected of students to develop toward the math subject during the implementation of the instructional units.

Gregorc Style Delineator (GSD) was administered to all subjects of the experiment to determine each individual student's learning style. Students were instructed to fill out the questionnaire based on their previous learning experience by rank ordering from 4 to 1 a series of four words which described students' different abilities. The administration of the test followed the standardized procedures outlined in the guide for the instrument.[4] A room was chosen to reduce potential outside disturbances. Participants were asked not to talk during the time allocated to the administration of the inventory. Clear directions were given and the need to react quickly to the words in the matrix was emphasized. The words in the matrix were not defined for the participants for the GSD requires the individual to actively and promptly connect the words with personal thoughts and feelings. Participants were permitted to talk among themselves for several minutes after the inventory was completed.

Following the completion of the inventory, the vertical columns of the four sets of words of the inventory were added by the researcher. This yielded to four scores representing the four learning styles: Concrete Sequential (CS), Abstract Sequential (AS), Abstract Random (AR), and Concrete Random (CR). The scores obtained were plotted in the Learning Style Profile to give students a graphic representation of their emphasis on one of the four styles. Based on these styles students were classified within each mathematics group in order to provide a teaching strategy that matched with the student's distinctive way of learning.

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[4] Ibid., p. 28.

Instructional Strategies

Based on the operational definitions given by Gregorc for the four constructs, the following strategies were implemented:

Concrete Sequential

The learners who showed this learning preference were provided with experiences they could share with other peers. Activities which required student's involvement and direct experience and active participation in discussions were provided. Step by step directions were given to this kind of learner. Presentations were clearly ordered and without distractions. Materials for this type of learner included workbooks, lectures accompanied by overhead transparencies, drawings or models, and hands-on material and equipment.

Abstract Random

The strategy for this kind of learner included lecturing, and students were given the opportunity to reflect on given situations. The teacher provided information in an unstructured matter and provided opportunity for group discussions. Other activities included short reading assignments followed by class activities, group or team work, film-strips with records, movies, television, and assignments that permitted reflection.

Abstract Sequential

These type of learners was provided with activities which required logical rational and analytical thinking. Teacher-directed activities in a structured environment was provided to this type of learner. The material was presented in a well organized environment without distractions. Teaching approach utilized readings, lectures, instructional and phonograph records.

Concrete Random

These kind of learners were provided with activities that involved doing things that relied on experimentation like projects, homework, and homework discussions. Other activities included games, simulations, independent study projects, optional reading assignments and problem solving activities.

The selection of the learning experiences and their organization and planning, and the implementation and evaluation of the instructional units was made by the researcher in collaboration with specialists in curriculum development, teachers, coordinators, and administrators of the Board of Education. Specialists from various universities were consulted for the preparation of the units. Once the instructional units were prepared, they were submitted to the consultants mentioned above for their analysis and reaction. Changes were made according to their suggestions.

Two instructional units were taught to each one of the four groups of students during three weeks. Each group was taught by using one of the four strategies described in previous paragraphs (CS, AS, AR, CR). Once the units were taught, students' achievement was measured by means of the achievement test (dependent variable). Students' attitudes toward the subject after the implementation of the instructional units were measured by the Attitude Inventory. The same inventory was administered before the implementation of the units.

Research Design

The Analysis of Variance (ANOVA) was used to analyze the data and to test the statistical hypotheses. The Statistical Package for Social Sciences (SPSS)[5] was the statistical computer program to perform this analysis. The ratio of observed differences/errors (F ratio) allowed the researcher to employ the variance (σ^2) of the four learning style group means as a measure of observed differences among groups. Since it was dealt with four different groups submitted to different treatments or teaching strategies, the ANOVA allowed the researcher to test the differences between two or more means. The ANOVA allowed the researcher to analyze the total variance of all the subjects in the experiment into two sources, variance among groups and variance within groups. The ANOVA also allowed the researcher to have an accurate picture of student's performance in comparison to other students within the same learning style group and to compare the results with other students submitted to a different treatment of different teaching strategy.

Since the population of this study consisted of Pre-Algebra and Algebra students of ninth and tenth grades, a Randomized Block design (RB-2) was used in order to avoid or isolate the effects of the differences in grades. RB-2 design isolates the effects of the nuisance variable by means of a blocking procedure where subjects who are homogeneous with respect to the grade are assigned to the same block.

The RB-2 design has some major disadvantages.[6] First, if a large

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[5]C. Hadda; Hull, et al., SPSS Update (New York: McGraw-Hill Book Company, 1979), pp. 136-137.

[6]Roger E. Kirk, Experimental Design (Belmont, CA: Wadworth, Inc., 1982), p. 298.

number of treatment levels are included in the experiment, it becomes difficult to form blocks or groups having minimum within block (group) variability. Second, if the fixed-effects and mixed (A random) models for a type RB-2 design, a test of treatment effects is negatively biased if (X)ij > 0. And third, the design involves somewhat more restrictive assumptions, for example, circularity, than the completely randomized design.

Following are the research questions and their correspondent null hypotheses:

Research Question 1

What is the statistical difference between the matching of the student's learning style with the teaching strategy and content acquisition: facts, concepts, and generalizations, as measured by achievement tests, in high school bilingual mathematic students?

Ho1: There is no statistically significant difference between the matching of the student's learning style with the teaching strategy and content acquisition: facts, concepts, and generalizations, as measured by achievement tests, in high school bilingual mathematic students.

Research Question 2

What is the statistical difference between the matching of the student's learning style with the teaching strategy, and the development of intellectual capabilities: observation, inference and prediction, as measured by achievement tests, in high school bilingual mathematic students?

Ho2: There is no statistically significant difference between the matching of the student's learning style with the teaching strategy, and the development of intellectual capabilities, as measured by achievement tests, in high school bilingual mathematic students.

Research Question 3

What is the statistical difference between the matching of the student's learning style with the teaching strategy, and the attitudes toward the subject; as measured by the Attitude Inventory, in high school bilingual mathematic students.

Ho3: There is no statistically significant difference between the matching of the student's learning style with the teaching strategy, and the attitudes toward the subject, as measured by the Attitude Inventory, in high school bilingual mathematic students.

Statistical Design

Dependent variables: Content acquisition scores

Intellectual capabilities scores

Attitudes toward the subject scores

Independent variables: Learning styles:

Concrete Sequential

Abstract Sequential

Abstract Random

Concrete Random

Teaching strategies:

Concrete Sequential Strategies

Abstract Sequential Strategies

Abstract Random Strategies

Concrete Random Strategies

Controlled Factors: Teacher

Ethnicity of subjects (all Hispanics)

English level (all subjects fall into levels 1, 2 and 3)

Treatment Groups: Four treatment groups (high school bilingual math students)

Statistic: ANOVA using 4 x 4 Randomized Block Design-2 to cells

Teaching Strategy

LEARNING STYLES	Treatment 1 CS Strategy	Treatment 2 AS Strategy	Treatment 3 AR Strategy	Treatment 4 CR Strategy
CS Students				
AS Students				
AR Students				
CR Students				

CHAPTER IV

RESULTS OF THE STUDY AND DISCUSSION OF FINDINGS

The previous chapters have presented a description of the nature of the problem, its theoretical bases, a review of the related literature, the methodology employed to test the statistical hypotheses, and the hypotheses under investigation. This chapter is concerned with a descriptive analysis of the research population and the results of the pre-tests and post-tests administered to the students to determine differences in achievement in content acquisition and the development of intellectual capabilities. A description of the results of the pre- and post-inventory to determine differences in attitudes toward the subject is also included in this chapter.

The data gathered from the tests and the inventory were subjected to extensive analysis in an effort to establish significant information in students' performances when their learning styles are matched with the teaching strategy. The results of the tests and the inventory were analyzed by utilizing the Statistical Package for Social Sciences (SPSSx). The hypotheses were tested by using the Analysis of Variance (ANOVA).

Description of the Students Under Study

Ninety-three students were classified according to their learning styles as identified by the Gregorc Style Delineator. All students were enrolled in one of the four bilingual algebra and pre-algebra classes. Each group was taught by using a different instructional strategy.

Table I presents a breakdown of the four strategies of teaching and the frequency distribution of the number of students who participated in each of those categories. Table II presents a breakdown of the four learning styles and the number of students belonging to each category. As it can be seen from Tables I and II, the subjects utilized for the experiment were almost uniformly distributed among the four categories. Graph I gives a pictorial representation of Tables I and II.

Table III presents a frequency distribution of the pre-test achievement scores in content acquisition. As it can be seen, 79 students or 85% scored less than or equal to four points out of twelve questions that measured content acquisition. The remaining 14 students or 15.% scored from five to nine points. Two students were absent the day the test was administered.

Table IV presents a frequency distribution of the pre-test achievement scores in intellectual capabilities. Eighty students (86.1%) scored less than or equal to six out of sixteen questions which measured intellectual capabilities. Seven students scored seven, nine, and eleven points. The remaining students had score of zero. Two students were absent the day of the test. The remaining four did not score in this category.

Table V shows the frequency distribution of the post-test achievement scores in content acquisition. Fifteen students (16.1%) scored three or less in this test. Forty-eight students or 51.6%

Table I

Frequency Distribution of the Number of Students Who Participated in Each Strategy of Teaching

Value Label	Value	Frequency	Percent
Concrete Random	1	23	24.7
Concrete Sequential	2	26	28.0
Abstract Random	3	23	24.7
Abstract Sequential	4	21	22.6
	Total	93	100.0

$\overline{X} = 2.452$ S.D. = 1.099

Table II

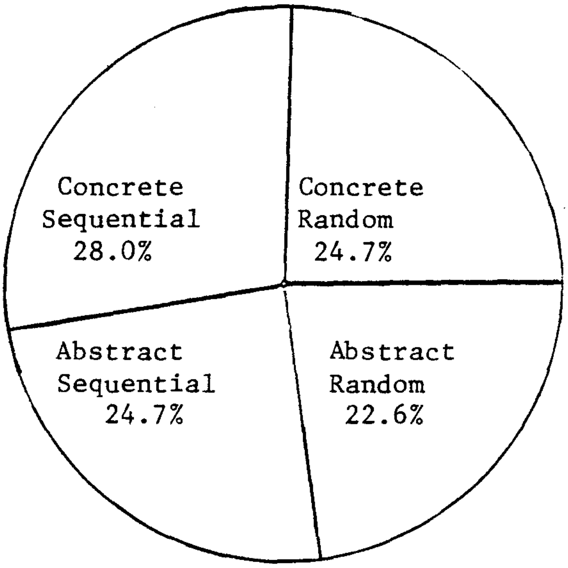
Frequency Distribution of the Number of Students in Each Style of Learning

Value Label	Value	Frequency	Percent
Abstract Sequential	1	21	22.6
Abstract Random	2	29	31.2
Concrete Sequential	3	21	22.6
Concrete Random	4	22	23.7
	Total	93	100.0

$\overline{X} = 2.473$ S.D. = 1.089

Graph I

Frequency Distribution of the Number of Students Who Participated in each Strategy of Teaching



Graph II

Frequency Distribution of the Number of Students in Each Style of Learning

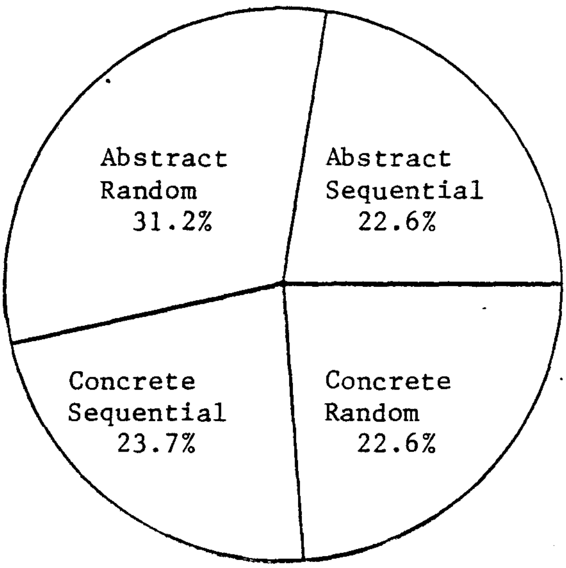


Table III

Frequency Distribution of Pre-Test Achievement Scores in Content Acquisition

N Questions Correct	Frequency	Percent	Valid Percent
1	8	8.6	8.8
2	37	39.8	40.7
3	21	22.6	23.1
4	13	14.0	14.3
5	6	6.5	6.6
6	2	2.2	2.2
7	2	2.2	2.2
9	2	2.2	2.2
0	2	2.2	Missing
Total	93	100.0	100.0

$\overline{X} = 2.978$ S.D. = 1.591

Table IV

Frequency Distribution of Pre-Test Achievement Scores in Intellectual Capabilities

N Questions Correct	Frequency	Percent	Valid Percent
1	5	5.4	5.7
2	17	18.3	19.5
3	22	23.7	25.3
4	17	18.3	19.5
5	11	11.8	12.6
6	8	8.6	9.2
7	5	5.4	5.7
9	1	1.1	1.1
11	1	1.1	1.1
0	6	6.5	Missing
Total	93	100.0	100.0

$\overline{X} = 3.805$ S.D. = 1.848

Table V

Frequency Distribution of Post-Test Achievement Scores in Content Acquisition

N Questions Correct	Frequency	Percent	Valid Percent
1	2	2.2	2.2
2	5	5.4	5.4
3	8	8.6	8.6
4	12	12.9	12.9
5	15	16.1	16.1
6	10	10.8	10.8
7	11	11.8	11.8
8	9	9.7	9.7
9	9	9.7	9.7
10	7	7.5	7.5
11	5	5.4	5.4
Total	93	100.0	

$\overline{X} = 3.805$ S.D. = 1.949

scored between four and seven. The remaining 30 students (32.3%) had a score of eight or more. Evidently, students scored better in the post-test in content acquisition compared with their pre-test results.

Table VI shows the frequency distribution of the post-test achievement scores in intellectual capabilities. Forty-eight students (51.6%) scored five or less points. The remaining 47.4% scored six or more points with two students absent from the post-test setting.

Table VII presents the frequency distribution of the scores attained in content acquisition and intellectual capabilities combined for the pre-test. Seventy-five students (80.8%) obtained nine points or less out of sixteen points in intellectual capabilities.

Table VIII presents the frequency distribution of the scores obtained in content acquisition and intellectual capabilities combined for the post-test. Fifty-nine students (63.8%) obtained ten or more points as compared to the scores in intellectual capabilities for the pre-test.

Table IX shows the frequency distribution of the pre-inventory scores in attitudes toward the subject. The mean for the pre-inventory was 5.930 with a standard deviation of 1.44. Table X shows the frequency distribution of the post-inventory scores in attitudes toward the subject of mathematics. The mean for the post-inventory was 5.899 with a standard deviation of 1.172.

Table XI presents a breakdown of the cell means of strategy and style in content acquisition. The table of means distribution of strategies of teaching shows that the group taught by the concrete sequential strategy had the highest mean ($\overline{X}$ = 4.27, n = 26). The

Table VI

Frequency Distribution of Post-Test Achievement Scores in Intellectual Capabilities

N Questions Correct	Frequency	Percent	Valid Percent
1	2	2.2	2.2
2	5	5.4	5.5
3	7	7.5	7.7
4	15	16.1	16.5
5	19	20.4	20.9
6	6	6.5	6.6
7	7	7.5	7.7
8	7	7.5	7.7
9	9	9.7	9.9
10	6	6.5	6.6
11	3	3.2	3.3
12	3	3.2	3.3
13	1	1.1	1.1
14	2	1.1	1.1
0	2	2.2	Missing
Total	93	100.0	

$\overline{X} = 6.220$ S.D. 2.936

Table VII

Frequency Distribution of Total Pre-Test Achievement Scores
(Content Acquisition and Intellectual Capabilities

N Questions Correct	Frequency	Percent	Valid Percent
3	6	6.5	7.0
4	10	10.8	11.6
5	11	11.8	12.8
6	16	17.2	18.6
7	14	15.1	16.3
8	9	9.7	10.5
9	9	9.7	10.5
10	3	3.2	3.5
11	4	4.3	4.7
12	1	1.1	1.2
13	1	1.1	1.2
14	1	1.1	1.2
15	1	1.1	1.2
	7	7.5	Missing
Total	93	100.00	100.00

$\overline{X} = 6.837$ S.D. = 2.552

Table VIII

Frequency Distribution of Total Post-Test Achievement Scores (Content Acquisition and Intellectual Capabilities)

N Questions Correct	Frequency	Percent	Valid Percent
2	1	1.1	1.1
5	3	3.2	3.3
6	5	5.4	5.5
7	5	5.4	5.5
8	10	10.8	11.0
9	8	8.6	8.8
10	7	7.5	7.7
11	6	6.5	6.6
12	5	5.4	5.5
13	6	6.5	6.6
14	4	4.3	4.4
15	4	4.3	4.4
16	3	3.2	3.3
17	5	5.4	5.5
18	3	3.2	3.3
19	7	7.5	7.7
20	4	4.3	4.4
21	2	2.2	2.2
22	2	2.2	2.2
23	1	1.1	1.1
	2	2.2	Missing
Total	93	100.0	100.0

$\overline{X}$ = 12.451 S.D. 4.967

Table IX

Frequency Distribution of the Pre-Inventory Scores in Attitudes Toward the Subject

Value	Frequency	Percent	Value	Frequency	Percent
3.71	1	1.1	6.01	1	1.1
3.73	3	3.2	6.10	1	1.1
3.80	1	1.1	6.11	2	2.2
3.90	1	1.1	6.13	1	1.1
4.00	3	3.2	6.15	1	1.1
4.10	1	1.1	6.20	1	1.1
4.58	1	1.1	6.23	1	1.1
4.60	1	1.1	6.30	2	2.2
4.80	3	3.2	6.47	1	1.1
4.86	1	1.1	6.50	1	1.1
4.90	3	3.2	6.61	1	1.1
4.93	1	1.1	6.65	2	2.2
5.00	3	3.2	6.66	1	1.1
5.12	1	1.1	6.71	7	7.5
5.14	1	1.1	6.81	1	1.1
5.22	1	1.1	6.87	1	1.1
5.26	1	1.1	6.90	2	2.2
5.27	1	1.1	7.00	4	4.3
5.38	1	1.1	7.01	1	1.1
5.40	4	4.3	7.08	2	2.2
5.42	1	1.1	7.12	1	1.1
5.44	1	1.1	7.20	1	1.1
5.45	1	1.1	7.23	2	2.2
5.47	1	1.1	7.25	1	1.1
5.60	1	1.1	7.30	2	2.2
5.68	1	1.1	7.50	1	1.1
5.70	2	2.2	7.60	1	1.1
5.73	1	1.1	7.65	1	1.1
5.81	1	1.1	7.78	1	1.1
5.90	2	2.2	7.93	1	1.1
5.95	1	1.1	9.10	1	1.1
			Total	93	100.0

$\overline{X} = 5.930$ S.D. = 1.44

Table X

Frequency Distribution of the Post-Inventory Scores in Attitudes Toward the Subject

Value	Frequency	Percent	Value	Frequency	Percent
2.60	1	1.1	5.95	1	1.1
3.33	1	1.1	6.10	2	2.2
3.72	3	3.2	6.12	1	1.1
3.82	1	1.1	6.13	2	2.2
4.00	1	1.1	6.32	2	2.2
4.13	2	2.2	6.34	1	1.1
4.25	1	1.1	6.35	1	1.1
4.30	1	1.1	6.46	1	1.1
4.31	1	1.1	6.47	1	1.1
4.50	1	1.1	6.50	3	3.2
4.55	1	1.1	6.61	1	1.1
4.60	1	1.1	6.66	3	3.2
4.80	1	1.1	6.71	5	5.4
4.90	1	1.1	6.72	1	1.1
4.93	2	2.2	6.83	1	1.1
5.00	4	4.3	6.86	1	1.1
5.10	1	1.1	6.90	1	1.1
5.17	1	1.1	6.92	1	1.1
5.26	1	1.1	6.94	1	1.1
5.28	1	1.1	6.98	1	1.1
5.40	3	3.2	7.00	2	2.2
5.45	1	1.1	7.10	1	1.1
5.50	4	4.3	7.16	2	2.2
5.52	1	1.1	7.25	1	1.1
5.67	1	1.1	7.30	2	2.2
5.68	1	1.1	7.37	2	2.2
5.70	2	2.2	7.49	1	1.1
5.74	1	1.1	7.50	1	1.1
5.80	2	2.2	7.60	1	1.1
5.83	1	1.1	7.80	1	1.1
5.88	1	1.1	8.07	1	1.1
5.93	1	1.1	8.65	1	1.1
			Total	93	100.0

$\bar{X} = 5.899$ S.D. = 1.172

Table XI

Cell Means of Difference in Test Scores in Content Acquisition as it Relates to the Strategy of Teaching

Concrete Random 1	Concrete Sequential 2	Abstract Sequential 3	Abstract Random 4
2.68	4.27	1.91	3.48
22	26	22	21

Cell Means of Difference in Test Scores in Content Acquisition as it Relates to the Style of Learning

Abstract Random 1	Abstract Sequential 2	Concrete Random 3	Concrete Sequential 4
3.86	2.52	3.35	3.05
21	29	20	21

second highest mean was obtained by the group taught by the abstract random strategy ($\overline{X}$ = 3.48, n = 21). The lowest scores were obtained by the group taught by the abstract sequential strategy ($\overline{X}$ = 1.91, n = 22) and the concrete random strategy ($\overline{X}$ = 2.68, n = 22).

In the same table of mean distribution, the mean of scores obtained by students of the same learning style across the four groups are shown. The abstract random group obtained the highest mean ($\overline{X}$ = 3.86, n = 21). The second highest mean was obtained by the concrete random group ($\overline{X}$ = 3.35, n = 20). The concrete sequential group obtained a mean of 3.05, n = 21. The lowest mean was obtained by the abstract sequential group ($\overline{X}$ = 2.52, n = 29).

Table XII presents a breakdown of the cell means of the interaction between strategy and style in content acquisition. In the group taught by the concrete random strategy, two groups had equal means: the concrete random ($\overline{X}$ = 4.00, n = 5) and the concrete sequential ($\overline{X}$ = 4.00, n = 5). Theoretically speaking, the concrete random group should have performed better since the strategy of teaching was addressed to this particular group.

The abstract random and the abstract sequential learning groups obtained the lowest means with 2.80 and .71, respectively when taught by CR strategy. The second group was taught by the concrete sequential strategy. As expected, the concrete sequential students had the highest mean ($\overline{X}$ = 4.57) when taught by CS strategy. However, the concrete random group obtained the lowest mean ($\overline{X}$ = 4.00). The abstract random group and the abstract sequential group had means of 4.40 and 4.11, respectively. These means are compared relative to the

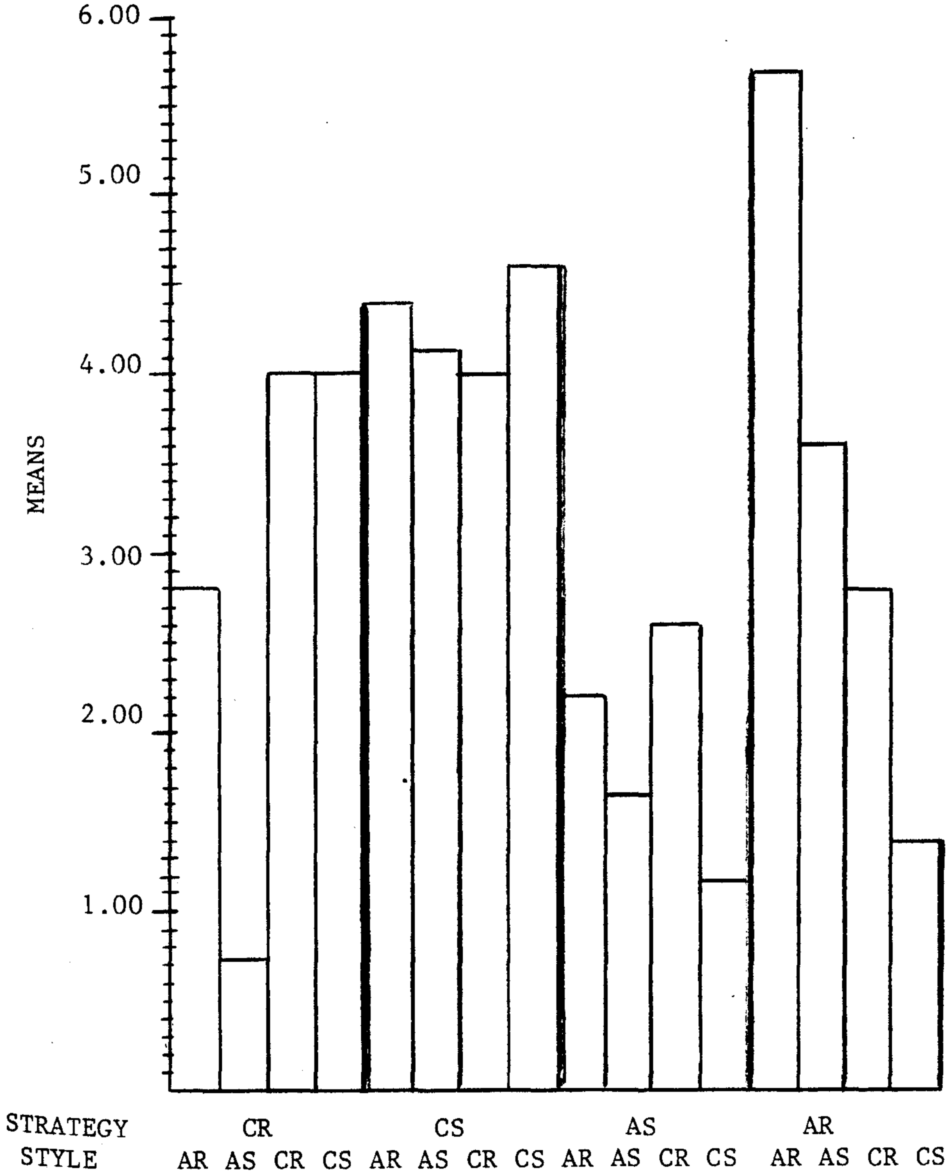
Table XII

Cell Means of Test Scores in Content Acquisition as it Relates to the Interaction Between Strategy of Teaching and the Style of Learning

STRATEGY OF TEACHING	STYLE OF LEARNING: CR	CS	AS	AR
CR	4.00 5	4.00 5	0.71 7	2.80 5
CS	4.00 5	4.57 7	4.11 9	4.40 5
AS	2.60 5	1.25 4	1.63 8	2.20 5
AR	2.80 5	1.40 5	3.60 5	5.67 6

GRAPH II

Cell Means of the Difference in Test Scores in Content Acquisition as it Relates to the Interaction Between Strategy of Teaching and Style of Learning



other means of the other styles within the same strategy of teaching.

The third group was taught by the abstract sequential strategy. Theoretically, group two, the abstract sequential, should have performed better; however, it had the second lowest mean ($\overline{X} = 1.63$). The highest means were obtained by the concrete random group and the abstract random group with 2.60 and 2.20, respectively. The concrete sequential group obtained the lowest mean of 1.25. Again, the means are compared relative to other means of the other styles within the same strategy of teaching.

The fourth group was taught by means of the abstract random strategy. As expected, the mean of this group was 5.67. The second highest mean ($\overline{X} = 3.60$) was obtained by the abstract sequential group. The concrete random group had a mean of 2.80 and the concrete sequential group had a mean of 1.40.

Description of the Hypotheses Analysis

The following is a discussion of the summary from the statistical analyses conducted to test each hypotheses. The results will be presented in that order.

Hypothesis #1

There is no statistically significant difference between the matching of the students' learning style with the teaching strategy and the content acquisition (facts, concepts, and generalizations) in high school mathematics bilingual students of a selected school.

Table XIII presents a display of the results of the two-way analysis of variance for teaching strategy by learning style. The main effect of strategy was found to be significant at $p < .02$, which

Table XIII

Analysis of Variance for the Interaction Between the Strategy of Teaching and the Style of Learning and Content Acquisition

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Main Effects	97.793	6	16.299	2.218	0.050
Strategy	74.691	3	24.897	3.388	0.022
Style	24.320	3	8.107	1.103	0.353
2-Way Interactions	79.434	9	8.826	1.201	0.307
Strategy Style	79.434	9	8.826	1.201	0.307
Explained	177.228	15	11.815	1.608	0.092
Residual	551.190	75	7.349		
Total	728.418	90	8.094		

shows that there is a significant difference for strategy in content acquisition. However, main effect for style was not found which shows that there is no statistically significant difference for learning style in content acquisition.

The two way interaction of teaching strategy by learning style was found not significant. The results indicate that the overall hypothesis failed to be rejected at the .05 level.

Table XIV reveals the cell means for strategy and style for the intellectual capabilities portion of the achievement test. The table of means distribution of strategies of teaching shows that the group taught by the concrete sequential strategy had the highest mean ($\bar{X}$ = 3.50, n = 26). The second highest mean was obtained by the group taught by the concrete random strategy ($\bar{X}$ = 2.64, n = 22). The lowest mean scores were obtained by the group taught by the abstract sequential strategy ($\bar{X}$ = 1.90, n = 20) and the abstract random strategy with a mean of 1.44, n = 18.

The table of means distribution for style shows the mean of scores obtained by the students of the same learning style across the four groups. The concrete sequential style obtained the highest mean ($\bar{X}$ = 3.44, n = 18). The second highest mean was obtained by the abstract random style ($\bar{X}$ = 3.19, n = 21). The lowest means were obtained by the abstract sequential style ($\bar{X}$ = 2.00, n = 28) and the concrete random style ($\bar{X}$ = 1.47, n = 19).

Table XV presents a display of the cell means of the interaction between the strategy of teaching and the learning style for the dependent variable of intellectual capabilities. In the group taught

Table XIV

Cell Means of the Difference in Test Scores in Intellectual Capabilities as it Relates to the Strategy of Teaching

Concrete Random 1	Concrete Sequential 2	Abstract Sequential 3	Abstract Random 4
2.64	3.50	1.90	1.44
22	26	20	18

Cell Means of the Difference in Test Scores in Intellectual Capabilities as it Relates to the Style of Learning

Abstract Random 1	Abstract Sequential 2	Concrete Random 3	Concrete Sequential 4
3.19	2.00	1.47	3.44
21	28	19	18

Table XV

Cell Means of Test Scores in Intellectual Capabilities as it Relates to the Interaction Between Strategy of Teaching and the Style of Learning

		STYLE OF LEARNING			
		CR	CS	AS	AR
STRATEGY OF TEACHING	CR	2.80 5	3.20 5	1.86 7	3.00 5
	CS	2.80 5	4.71 7	1.89 9	5.40 5
	AS	0.20 5	3.00 4	2.71 8	1.80 5
	AR	-0.25 5	1.33 5	1.40 5	2.67 6

by the concrete random strategy, the highest mean was obtained by the concrete sequential group ($\overline{X}$ = 3.20, n = 5). The second highest mean score was obtained by the abstract random style ($\overline{X}$ = 3.00, n = 5). The third highest mean score was obtained by the concrete random group ($\overline{X}$ = 2.80, n = 5). The lowest mean ($\overline{X}$ = 1.86, n = 7) was obtained by the abstract sequential group.

Another group was taught by the concrete sequential strategy. However, the concrete sequential group obtained the second highest mean ($\overline{X}$ = 4.71, n = 7) while the highest mean was obtained by the abstract random group ($\overline{X}$ = 5.40, n = 5). The concrete random group obtained a mean of 2.80, n = 5 and the abstract sequential group had the lowest mean ($\overline{X}$ = 1.89, n = 9).

A third group was taught by the abstract sequential strategy. The highest mean score was obtained by the concrete sequential group ($\overline{X}$ = 3.00, n = 3). The second highest mean score was obtained by the abstract squential goup ($\overline{X}$ = 2.71, n = 7) which would be anticipated as being the highest score. The abstract random group had a mean of 1.80, n = 5 and the concrete random group obtained the lowest mean ($\overline{X}$ = .20, n = 5).

The final group was taught by means of the abstract random strategy. The abstract random group of students had the highest mean ($\overline{X}$ = 2.67, n = 6). The concrete sequential group had the second highest mean ($\overline{X}$ = 1.40, n = 5). The lowest scores were obtained by the abstract sequential style group ($\overline{X}$ = 1.40, n = 5) and the concrete random group ($\overline{X}$ = -0.25, n = 5).

Hypothesis #2

There is no statistically significant difference between the matching of the students' learning style with the teaching strategy and the development of intellectual capabilities (observation and inferences) in high school mathematic bilingual students of a selected school.

Table XVI presents the results of the two-way analysis of variance for the teaching strategy by learning style. The main effect for strategy was not found to be significant. Main effect for style was not found either. Therefore, the findings show that there is no statistically significant difference for either strategy or style in the main effects of the development of intellectual capabilities.

The two-way interaction of teaching strategy by learning style obtained an $F\ (9,93) = .793,\ p > .05$. Therefore, the results indicate the overall hypothesis was not rejected at the .05 level.

The cell means of strategy and style for the dependent variable of attitudes toward the subject are revealed in Table XVII. The table shows that the group taught by the concrete random strategy had the highest mean difference ($\overline{X} = .28$, $n = 23$), followed by the group taught by the abstract sequential strategy ($\overline{X} = .05$, $n = 23$). The students taught by the concrete sequential strategy, both obtained negative means difference of $\overline{X} = -0.07$, $n = 26$ and $\overline{X} = -0.40$, $n = 21$, respectively.

The table also shows the mean difference distribution for style of learning. The concrete random group obtained the highest mean difference ($\overline{X} = 0.14$, $n = 21$). The second highest mean difference ($\overline{X}$

Table XVI

Analysis of Variance for the Interaction Between the Strategy of Teaching and the Style of Learning and Intellectual Capabilities

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Main Effects	105.331	6	17.555	2.392	0.037
Strategy	52.297	3	17.432	2.375	0.077
Style	51.713	3	17.238	2.349	0.080
2-Way Interactions	52.369	9	5.819	0.793	0.624
Strategy Style	52.369	9	5.819	0.793	0.624
Explained	157.700	15	10.513	1.432	0.157
Residual	513.753	70	7.339		
Total	671.453	85	7.899		

Table XVII

Cell Means of Differences in Scores in the Attitudes Inventory as it Relates to the Strategy of Teaching

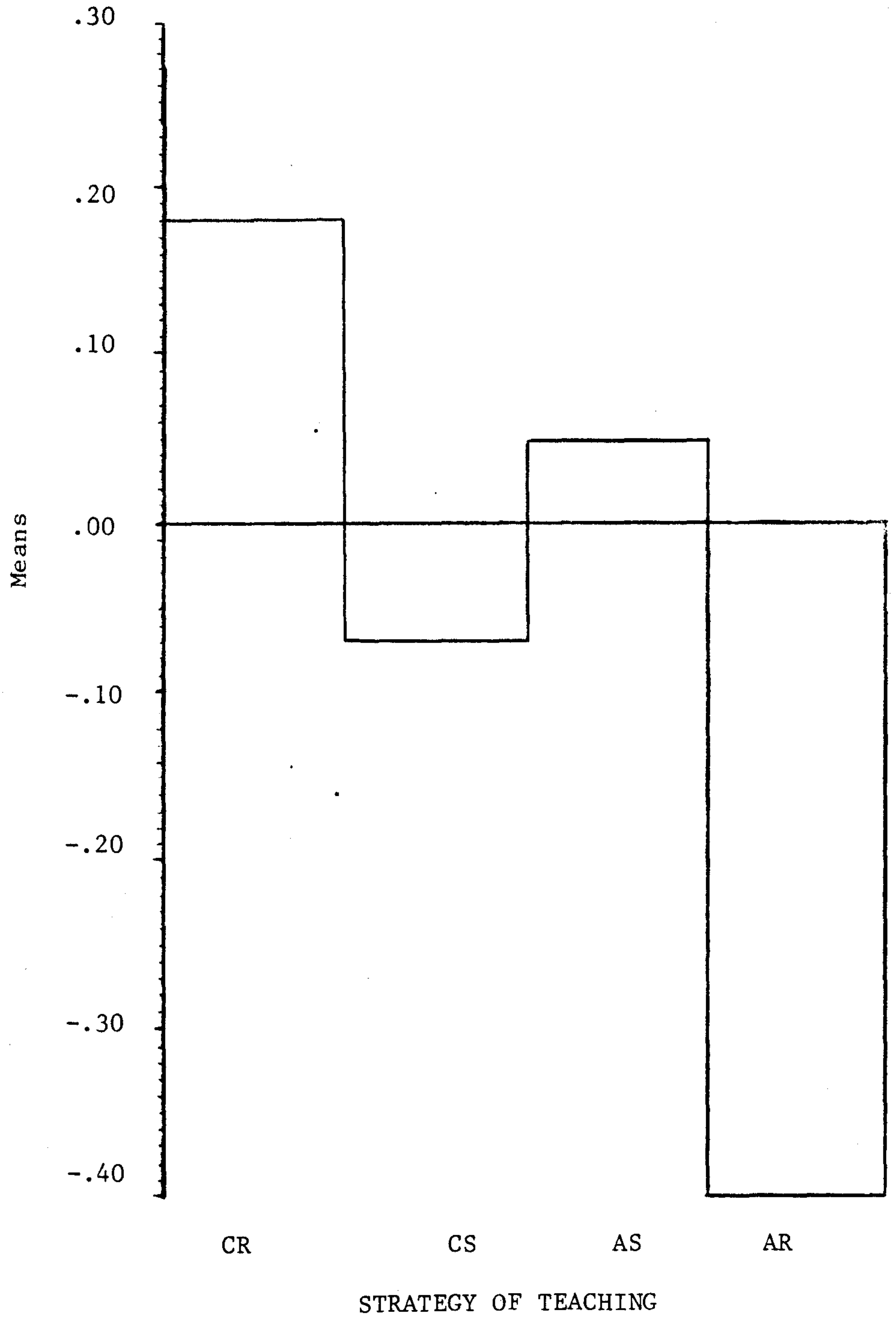
Concrete Random 1	Concrete Sequential 2	Abstract Sequential 3	Abstract Random 4
0.28	-0.07	0.05	-0.40
23	26	23	21

Cell Means of Differences in Scores in the Attitudes Inventory as it Relates to the Style of Learning

Abstract Random 1	Abstract Sequential 2	Concrete Random 3	Concrete Sequential 4
-0.52	0.12	0.14	0.08
21	29	21	22

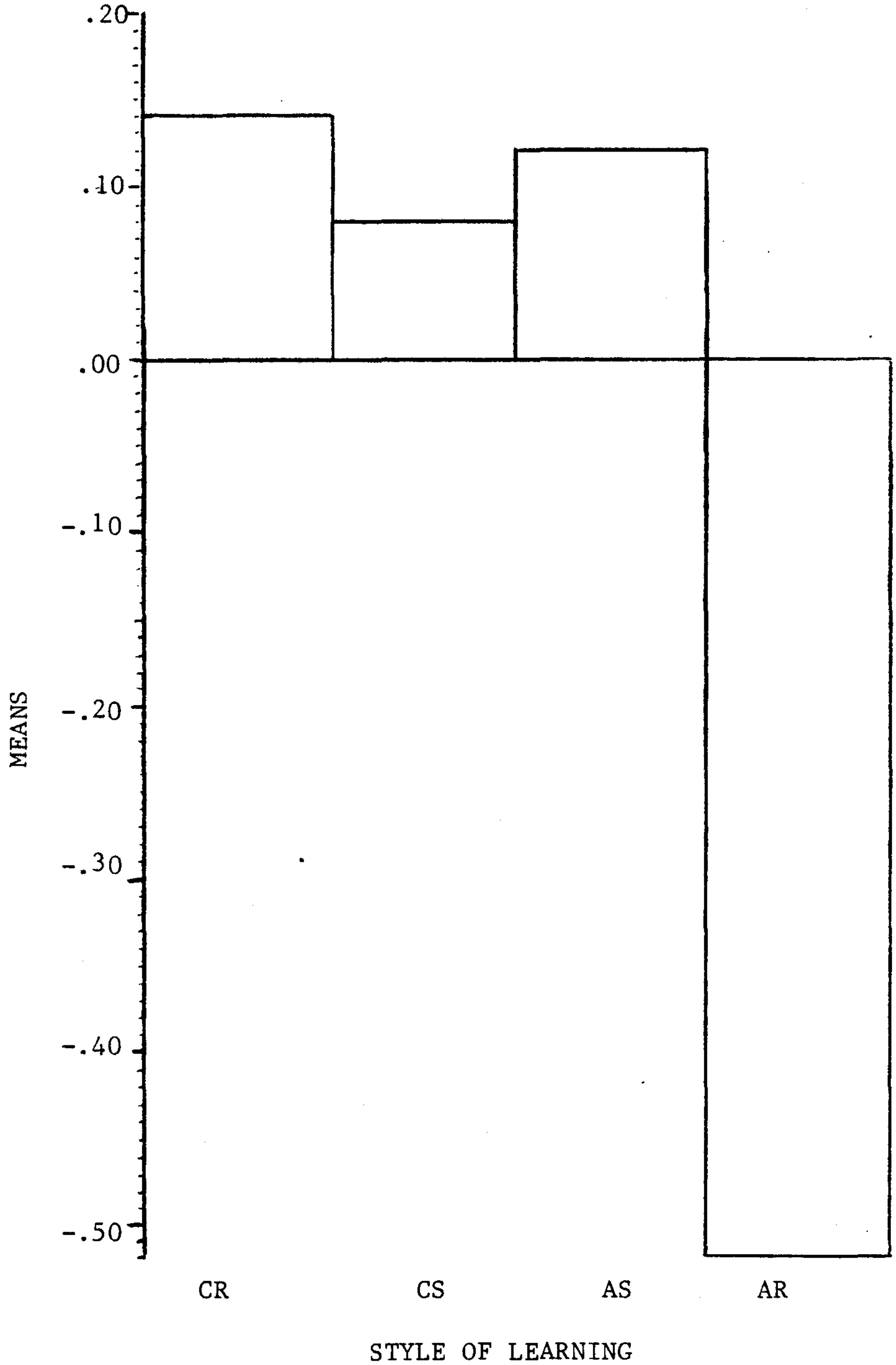
Graph IV

Cell Means of the Difference in Scores in the Attitudes Inventory as it Relates to the Strategy of Teaching



Graph V

Cell Means of the Difference in Scores in the Attitudes Invento ry as it Relates to the Style of Learning



= .12, n = 29) was obtained by the abstract sequential group. The concrete sequential group obtained a 0.08, n = 22 while the abstract random group obtained a negative mean difference of -0.52, n = 21.

The cell means for the interaction between the strategy of teaching by the style of learning is revealed in Table XVIII. The mean differences for these interactions are all very low and, in some cases, negative. For the group taught by the concrete random strategy, the highest mean difference ($\bar{X}$ = .52, n = 5) was obtained by the abstract random group. The second highest mean difference ($\bar{X}$ = .41, n = 5) was obtained by the concrete sequential style group. The two lowest means differences were obtained by the abstract sequential and the concrete random groups with $\bar{X}$ = 0.29, n = 7 and $\bar{X}$ = -.06, n = 6, respectively. The concrete random group was theoretically supposed to have the largest mean, since the strategy of teaching was addressed to this particular group.

The highest mean difference for the group taught by the concrete sequential strategy was obtained by the concrete sequential style group ($\bar{X}$ = .41, n = 5. The concrete random group obtained the second highest mean difference ($\bar{X}$ = .37, n = 5). The two lowest mean differences were negative and were obtained by the abstract random ($\bar{X}$ = -.70, n = 5) and the abstract sequential ($\bar{X}$ = -.035, n = 9).

A third group was taught by the abstract sequential strategy. The abstract sequential group obtained the highest mean difference ($\bar{X}$ = .54, n = 5). The other three mean differences were negative: the concrete random style ($\bar{X}$ = -0.01, n = 5), the concrete sequential style ($\bar{X}$ = -0.25, n = 5) and the abstract random style ($\bar{X}$ = -.37, n =

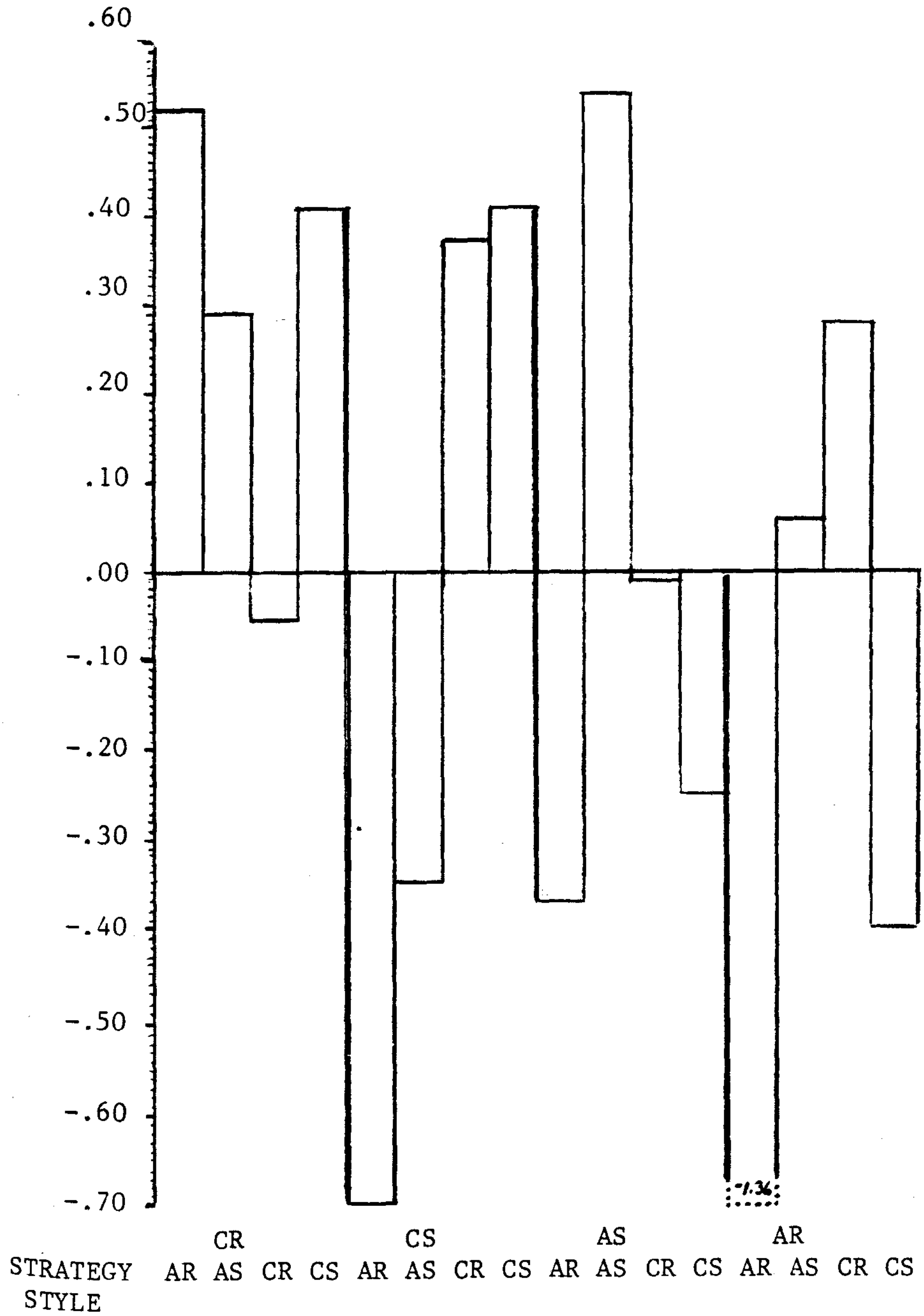
Table XVIII

Cell Means of the Attitudes Inventory as it Relates to the Interaction Between Strategy of Teaching and the Style of Learning

STRATEGY OF TEACHING	STYLE OF LEARNING CR	CS	AS	AR
CR	-0.06 6	0.41 5	0.29 7	0.52 5
CS	0.37 5	0.41 7	-0.35 9	-0.70 5
AS	-0.01 5	-0.25 5	0.54 8	-0.37 5
AR	0.28 5	-0.40 5	0.06 5	-1.36 6

Graph VI

Cell Means of the Difference in Scores in the Attitudes Inventory as it Relates to the Interaction Between the Strategy of Teaching and the Style of Learning



5).

The highest mean difference for the group taught by the abstract random strategy was obtained by the concrete random group ($\overline{X}$ = .28, n = 5). The abstract sequential group had a mean of .06, n = 5. Two negative mean differences were obtained by the concrete sequential style ($\overline{X}$ = -0.40, n = 5) and the abstract random style ($\overline{X}$ = -1.36, n = 6).

Hypothesis #3

There is no statistically significant difference between the matching of the students' learning style with the teaching strategy and the attitudes toward the subject in bilingual students in high school mathematics in a selected school.

Table XIX presents a display of the results for the analysis of variance of the teaching strategy by the attitudes toward the subject of mathematics. Main effect by strategy was not found to be significant nor was the main effect by style.

The two-way interaction of teaching strategy by learning style for the dependent variable of attitudes difference scores toward the subject was found not significant. The results indicate that the overall hypothesis failed to be rejected.

Discussion of Findings

This section deals with the discussion and interpretation of the research findings. A review of the theoretical considerations affected by the results of the study is also included.

This study investigated the relationship between the individual student's learning style when matched with teaching strategy and

Table XIX

Analysis of Variance for the Interaction Between the Strategy of Teaching and the Style of Learning and the Attitudes Towards the Subject

Source of Variation	Sum of Squares	DF	Mean Square	F	Significance of F
Main Effects	11.143	6	1.857	1.346	0.247
Strategy	4.656	3	1.552	1.125	0.344
Style	5.880	3	1.960	1.421	0.243
2-Way Interactions	12.644	9	1.405	1.019	0.433
Strategy Style	12.644	9	1.405	1.019	0.433
Explained	23.787	15	1.586	1.150	0.329
Residual	106.207	77	1.379		
Total	129.994	92	1.413		

content acquisition, the development of intellectual capabilities, and the attitudes toward the subject of mathematics. Upon investigation, such a relationship was not found to exist at statistically significant levels. A closer look to the findings of the study will help to understand its implications.

The results of the pre-test achievement scores (Table III) showed that students had very little knowledge of the topic of equations since 86.8% scored four points or less out of a possible twelve points in content acquisition (items correct). However, 64.8% scored more than five points after the instructional units were implemented. The median of the pre-test was two while the median for the post-test was six. Although there was an increase in students' knowledge on the topic of equations, it is not very impressive. It should be noted that the results of these tests refer to the achievement of the group as a whole. From the perspective of the learning style theory, this little difference in the scores in content acquisition of the group as a whole can be attributed to the fact that only about 23% of the students were benefiting from the teaching strategy that was matched for them, or, stated differently, 77% of the students were mismatched with the teaching strategy. As a result, they didn't benefit from the instructional strategy.

The results of the pre- and post-tests in intellectual capabilities showed similar results. Eighty-six percent of the students scored less than six points out of sixteen in the pre-test of intellectual capabilities. This group obtained a median of two. In the post-test of intellectual capabilities, 47.3% scored six or more points. The median for the post-test was four. Again, the small difference in the development of intellectual capabilities could be attributed to the fact that about 77% of the students were not provided with the appropriate teaching strategy. Theoretically, students were expected to score less on this part since intellectual capabilities refer to higher levels of thinking and learning. When the two variables of content acquisition and intellectual capabilities were combined in the pre-test and also in the post-test, similar results were obtained, as when the variables were considered separately.

The cell means of test scores in content acquisition (Table XII) shows a tendency to obtain better results when the learning style is matched with the teaching strategy. However, the statistical analysis shows the results to be not significant. For the first group (taught by the concrete random strategy), students with a concrete random style were suppose to perform better since the teaching strategy was matched for this particular group of students. This group, however, performed the same as the concrete sequential group. Although the teaching strategies were different for these two groups, they were both taught through concrete strategies. Whether the strategy was sequential or random did not seem to have much impact in these students' learning.

It is not surprising that the abstract sequential students had the lowest mean scores ($\overline{X}$ = 71) since it presented a completely different style to the one for which the teaching strategy was provided. On the other hand, the students classified as abstract sequential within this group were the students of lower academic achievement by virtue of mismatch and a tendency to perform poorly when confronted with "concrete" instruction.

In the second group, the students with the concrete sequential style performed better as expected obtaining the higher mean ($\overline{X}$ = 4.57). However, the other group in that category, the concrete random, performed similarly with a range between them of .57. This is the most homogeneous group in academic achievement, so the results are not surprising. This group, the concrete sequential, should have performed at a higher level since they were algebra students. To some extent, they were familiarized with the topic of equations from their previous pre-algebra course. Besides, they were more familiarized with some of the terminology used in algebra during the first part of the semester. When compared with the means in content acquisition of the other three groups taught by different strategies, no significant increase in achievement is shown. In fact, one of the other groups (the abstract random style of the fourth group) obtained a higher mean ($\overline{X}$ = 5.67).

In the third group, taught by the abstract sequential strategy, the concrete random group obtained the highest mean, although very low ($\overline{X}$ = 2.60), compared to the means of other instructional strategy groups. The results of this group were totally unexpected since the abstract sequential group was supposed to perform better. It is also important to point out that this group was the lowest in academic achievement.

Group four was taught by the abstract random strategy. From a learning style theory point of view this group performed perfectly. The abstract random style students had the highest mean ($\overline{X}$ = 5.67) followed by the abstract sequential group ($\overline{X}$ = 3.60). The concrete random group obtained the third mean ($\overline{X}$ = 2.80) followed by the concrete sequential group with the lowest mean ($\overline{X}$ = 1.40). Again, the group that obtained the highest mean, the abstract random was the group of students with the highest level of academic achievement and the group that obtained the lowest mean was the group of students with the lowest level of academic achievement.

The results of the test scores in academic achievement showed lower mean scores in intellectual capabilities than in content acquisition. This is conceivable since intellectual capabilities imply a higher level of thinking and learning. Only one of the four groups, the abstract random, obtained an expected mean in relation to other styles within the same group. But still it was a very low mean ($\overline{X}$ = 2.67), much lower than the mean the same group obtained in content acquisition ($\overline{X}$ = 5.67).

The other three groups taught by the concrete random, the concrete sequential, and the abstract sequential strategies, obtained completely unexpected results. In fact, students who performed better in each of those groups belonged to other category than the one they were taught. For example, in the group taught by the concrete random strategy, the abstract random group performed better. A similar observation can be made for the group taught by the abstract sequential strategy. In this case, the concrete sequential group obtained the highest mean. Apparently, the abstract random group responded better to the random aspect of the concrete random strategy than to the abstract aspect of teaching. Stated differently, those students responded better to the flexiblity of the structure and the variety of sources used by the teacher during the learning experience. In the same way, the concrete sequential group responded better to the sequential aspect of the abstract sequential strategy than to the abstract aspect of the strategy. In other words, those students responded better to the structured, linear or successive aspect of the teaching strategy. In the group taught by the concrete sequential strategy the abstract random style obtained the highest mean.

Interestingly, only in the group taught by the abstract random strategy, the expected style, the abstract random, obtained higher means in both content acquisition and intellectual capabilities. The other three groups obtained different higher means in content acqusition and intellectual capabilities. These findings might suggest that the matching of the teaching strategy with the learning style could be more suitable to teach content acquisition than for the development of intellectual capabilities.

Another interesting comparison is the fact that the highest mean in intellectual capabilities was obtained by the group taught by the concrete sequential strategy, although that mean was obtained by the abstract random group. In content acquisition the highest mean was obtained by the group taught by the abstract random strategy.

When we compare the means of the groups taught by the concrete strategies with the groups taught by the abstract strategies, the members in the first group performed better than the members in the second category. There is a tendency for the population of this study to perform better when concrete strategies of teaching are employed.

The cell means of the attitude´s inventory do not show any significant findings in terms of the attitudes toward the subject and the matching of the students´ learning style with the teaching strategies. In fact, the analysis of variance didn´t show any statistically significant differences between the pre- and the post-inventory at the .05 level. In many cases, students who were expected to develop better attitudes toward the subject had a higher average in the pre-inventory than in the post-inventory. This might be due to the fact that students were more spontaneous during the answering of the first inventory, but were more rational in answering the second time since they were more familiar with the instrument.

General Considerations

Although this study shows that, in some cases, students had a tendency to perform better when their learning style was matched with the teaching strategy, the two-way analysis of variance showed no significant interaction between the strategy of teaching and the style of learning for any of the three variables under consideration: content acquisition, intellectual capabilities or attitudes toward the subject of mathematics.

The researcher found it a difficult task to implement the whole instructional unit in purely abstract or concrete form. Mathematics is a subject which combines abstraction and concreteness as do most subjects. Some concepts are better explained by abstract means while others need concrete means to be explained. In other words, the emphasis during the teaching process relies on abstract or concrete means depending on the nature and degree of difficulty of the topic discussed some times disregarding the students' preferred way of learning. The researcher's commitment to maintain the purity of the teaching strategies as defined by Gregorc made it difficult to get some ideas across during the teaching process especially with the abstract style students. This fact might have limited students from learning some knowledge that could be taught more efficiently by using a concrete approach; consequently, students might have obtained lower scores in the achievement tests due to the rigidity of the teaching strategy.

Another variable that might have influenced the low test scores is the fact that students depended only on the classroom learning experiences. Students were instructed not to ask any other teacher or person outside the classroom. No homework was required from students during the time of the experiment.

The topic of equations have traditionally been a difficult topic to teach since it requires the mastery of basic operations with real numbers. Although these operations were taught before the implementation of the instructional units, students usually require several months of practice to completely master them. It is probable that students needed a longer period of time to master the concept of equations which requires the use of the basic operations with real numbers. This additional time would have given them the opportunity to obtain better scores in the achievement tests.

Another variable that might have affected the results of this study is the fact that the experiment had to be postponed due to a teacher's strike. Students' attitudes toward the subject and toward learning might have been negatively affected by the strike. A related factor is that the units had to be implemented during the last two weeks of the first semester school year.

A final point is related to the Style Delineator, the instrument used to identify students' learning styles. The inventory was administered twice. The first time, it was administered two months in advance to the implementation of the instructional units. The instructions given by the administration manual, An Adults Guide to Style were followed as indicated. The learning styles identified by the Delineator in this occasion were the ones used for the experiment. However, students continuously expressed that they had guessed in answering the inventory since they didn't understand most of the words of the four categories of the Delineator. A month later, the inventory was discussed with the students, the terms were defined, and it was administered again. Seventy-five percent of the students revealed a different learning style.

This finding raises serious questions about the validity and reliability of the Delineator when used with bilinguals who have not made the transition to English language dominant. Even during the implementation of the instructional units students whose identified learning style was matched with the teaching strategy expressed dissatisfaction with the teaching approach being used. This gives the researcher reason to believe that the student's learning styles were not accurately identified. Had the Delineator accurately identified the students' learning style, no negative feelings should have been expressed and better scores should have been obtained in the achievement tests.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this investigation was to determine the statistical difference between the matching of the student's learning style with the teaching strategy and the content acquisition, the development of intellectual capabilities, and the attitudes toward the subject of bilingual high school mathematic students. The independent variables of the study were the teaching strategy and the learning style. The dependent variables were students' achievement in content acquisition, the development of intellectual capabilities and the attitudes toward the subject.

Four basic learning styles were identified and labeled abstract sequential, abstract random, concrete sequential, and concrete random. Based on these four learning styles, four teaching strategies were developed.

More precisely, the questions underlying this investigation were the following:

1. Is there a statistically significant difference between the matching of the students' learning style and the content acquisition: facts, concepts and generalizations, in bilingual high school mathematics students of a selected school?

2. Is there a statistically significant difference between the

matching of the students' learning style with the teaching strategy and the development of intellectual capabilities: observation, inferences (predictive, generalizing or explanatory) in bilingual high school mathematics students of a selected school?

3. Is there a statistically significant difference between the matching of the students' learning style with the teaching strategy and the attitudes toward the subject in bilingual high school mathematics students of a selected school?

The statistical analysis using SPPSx did not evidence statistically significantly higher test scores at the .05 level. Thus, this research data does not substantiate the theoretical construct that students evidence statistically higher achievement test scores when they are taught in ways that complement their individual learning styles.

Subjects

The subjects for this study were drawn from the population of ninth and tenth grade Hispanic bilingual students attending Kelvyn Park Public High School in Chicago, Illinois. Ninety-three Spanish-speaking students enrolled in algebra and pre-algebgra classes participated in the experiment. All students fell within categories 1, 2, and 3 of proficiency in the English language.

Instrumentation

The subjects were administered the Gregorc Style Delineator. Four constructs were identified by the Style Delineator: concrete sequential (CS), abstract sequential (AS), concrete random (CR) and abstract random (AR). The Style Delineator describes the degree to which an individual sees himself or herself in relationship to each of these four constructs. All subjects were classified according to their learning style.

An achievement test was administered in a pre-post bases to compare differences in content acquisition and the development of intellectual capabilities. The test consisted of 28 items, 12 of them measured content acquisition and 16 of them measured intellectual capabilities.

The attitudes toward the subject were measured by an Attitude Inventory administered in a pre-post bases. The test consisted of 15 items. An average attitude score was computed for each student. The average score was determined separately, for the student's pre-test responses and his post-test responses. The averages were compared to establish differences in attitudes toward the subject.

Procedures

The Gregorc Style Delineator was administered to all 93 subjects of the experiment to determine each individual student learning style. The Style Delineator was administered following the guidelines of the basic manual, An Adult's Guide to Style. The classroom was chosen to reduce any potential outside disturbances. The words in the matrix were not defined so that students could actively and promptly connect the words with personal thoughts and feelings. The four columns of the inventory were added, yielding to four scores representing the four learning styles: concrete sequential, abstract sequential, abstract random, and concrete random. Based on these scores students were classified within each mathematics group according to their style of learning. The teaching strategy was matched with the students' learning style, and learning experiences were provided accordingly.

Once the students were classified according to their style of learning, a pre-test was administered to measure students' knowledge on the topic of equations. After the instructional units were taught, the test was administered again in order to make a comparison of the results. The attitude inventory was simultaneously administered in both occasions to compare differences in attitudes before and after the instructional units were taught. All students were aware of the study being conducted.

Duration of the Study

This study was conducted during the first semester of the school year, 1984-85. For a period of two weeks the topic of equations was taught simultaneously to all subjects of the experiment. The learning style inventory was administered a month in advance. The pre- and post-tests and the pre- and post-attitude inventories were administered at the beginning and the end of the two week period.

Research Design

A separate statistical two-way Analysis of Variance (ANOVA) procedure was performed to test the statistical hypotheses. For the data analysis, hypotheses were tested at the .05 level of significance. A randomized block design (RB-2) was used in order to isolate the effects of the difference in grades of the students of the experiment.

Findings

Following the analysis of the students' data through a two-way

ANOVA procedure, the null hypothesis regarding difference in achievement in content acquisition (facts, concepts, and generalizations) when the teaching strategy was matched with the learning style failed to be rejected at the .05 level. Also, the null hypothesis regarding difference in the development of intellectual capabilities (observation and inferences) when the teaching strategy was matched with the learning style failed to be rejected at the .05 level.

The statistical procedures showed no significant difference in the attitudes toward the subject when the teaching strategy was matched with the learning style. Thus, the null hypothesis failed to be rejected at the .05 level of significance.

Conclusions

This investigation was conducted in a Chicago Public High School bilingual education setting with the participants' knowledge, under normal classroom procedures and conditions, and without external manipulation of students' programs or schedules. The researcher was the teacher who implemented the instructional units. The following conclusions were drawn from the analyses of the generated data and may not be generalized to other populations and situations. The design used for this study, the instruments used to measure its variables, and the procedures used to select participants for the research intend to serve only the purpose of this investigation.

The population of this study as well as the procedures were selected because related research at the senior high school bilingual mathematics are virtually non-existent since most studies have been conducted at college level, elementary level, and in other subjects, within the regular program.

The dependent variables of this research were the test scores in content acquisition, the test scores in intellectual capabilities and the calculated average difference in the attitude inventory. The independent variables were the teaching strategies employed by the teacher and the identified student's learning styles.

No significant interaction was observed between the matching of the students' learning style with the teaching strategy and the content acquisition (facts, concepts and generalizations) in high school mathematics bilingual students. Thus, when students were identified as having an abstract sequential, abstract random, concrete sequential or concrete random way of learning and they were taught with the teaching strategy according to their style, their achievement test scores were not statistically significantly higher than those students whose learning style was mismatched with the teaching strategy. This data failed to corroborate the hypothesis that when students are instructed in ways that complement their learning styles, achievement increases significantly.

The lack of interaction between the matching of the learning style with the teaching strategy, and the development of intellectual capabilities in the mathematics achievement test scores indicated that the matching did not have a positive influence. Thus, the outcome did not support the anticipated result that students perform better when the teaching strategy was matched with their learning style.

This study data indicated that the hypothesis of obtaining an interaction between the matching of the students' learning style with the teaching strategy was not supported by the findings. Students were expected to develop more positive attitudes toward the subject as a function of being taught through a strategy that matched their learning style. The results, however, did not show such interaction.

Recommendations

The findings of this study should both influence and cause revision of several aspects of the learning style approach. This section focuses on specific recommendations for future research.

1. Replication of the present study - The literature supports the need to conduct more studies that seek interaction between the learning styles and the teaching strategies. Until this study is replicated few conclusive generalizations can be made especially when this study contradicts previous findings which support the thesis that students perform better when their individual learning styles are matched with the teaching strategies.

2. A similar study should be conducted for a greater length of time and with a larger population. The present study was designed to include only one unit for a two week period. It would be beneficial to implement several units of different levels of difficulty. It is speculated that the short duration of this study may have unduly influenced the results. It is quite possible that the effects of the teaching strategy, when matched with the students' learning styles were not able to evidence in that short period of time.

It is conceivable, too, that the sample size affected the final results. The outcome might have been different had a larger sample been utilized. In a larger population, the means and standard deviations would have been more representative of the population mean.

3. It is recommended that a similar study be conducted at the beginning of a school year. The present study was conducted at the end of the first semester after being postponed due to a teachers' strike. It is conceivable that, due to the strike, students' atitude toward learning might have been negatively affected and, consequently, the results of the experiment. The fact that at the end of the semester students are involved in studying for final exams could have also affected the outcome of the study.

4. As an outgrowth of this investigation, another might study and analyze how the same group of students perform when taught by other teaching strategies that do not match their identified learning style. For the purpose of this study, students were classified within each group as abstract sequential, abstract random, concrete sequential or concrete random. The entire group was taught by matching one of those identified learning styles. This study provides no evidence as to how the same group that was matched would have performed in test of achievement and attitudes toward the subject if they were taught by other teaching strategies.

5. It is suggested that a similar study be undertaken without the participants' knowledge of the experiment being conducted. The IRB for the protection of human rights requested the participants' knowledge of, and voluntary participation in the experiment. This fact might have affected students' spontaneous participation in class and the natural setting of the classroom.

6. Replication of this study is advocated to other schools within the same school district and other school districts with students of similar characteristics. This would permit generalizations about peculiarities of the bilingual students way of learning.

7. Experimentation with other subject matters is also suggested. Mathematics is essentially an abstract and analytical subject, so it would be of interest to see how students perform in other subject matters (e.g. science or social studies) when the teaching strategy is matched with the learning style. This would permit improved generalizations of the results and more systematic verification of the effects of matching in diverse disciplines.

8. A repetition of this study utilizing a trained teacher other than the researcher might minimize the effects of any bias that might have occurred as a researcher expectations of the outcomes.

9. Finally, it is recommended that the Gregorc Style Delineator, the instrument used to identify the students' learning styles, should be reviewed and submitted to continuing validation. The instrument was administered following the instructions of the administration manual, however, students expressed serious concerns about understanding most of the words of the inventory. In fact, the administration of the instrument in a second occasion to the same group of students, resulted in different learning styles in 70% of the students. Other means should be developed in order to make accurate identification of the students' learning styles.

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APPENDIX A

ACHIEVEMENT TEST OF CONTENT ACQUISITION AND INTELLECTUAL CAPABILITIES

NOMBRE: FECHA:

TEMA : ECUACIONES PUNTUACION:

Instrucciones: Haz un círculo alrededor de la letra correspondiente a la mejor contestación. Lee todas las alternatives antes de hacer tu selección.

1. Una ecuación es:

   a. una expresión algebraica que contiene una o más variables
   b. una expresión algebraica que contiene varias operaciones con una variable
   c. una relación de igualdad entre dos expresiones matemáticas
   d. una relación de similaridad entre dos expresiones matemáticas

2. Una ecuación tiene por los menos:

   a. un término a cada lado del signo de igualdad
   b. dos términos a cada lado del signo de igualdad
   c. dos términos al lado izquierdo y uno al lado derecho
   d. dos términos y una variable al lado izquierdo y un número al lado derecho

3. Cada término de una ecuación consiste de:

   a. un número positivo o negativo
   b. una variable positiva o negativa
   c. el producto de un número y una variable
   d. cualquiera a, b, o c

4. La solución de una ecuación es:

   a. el valor de cada término de la ecuación
   b. el valor que hace cierta la ecuación
   c. el valor de cada lado de la ecuación
   d. el valor del coeficiente de la variable

5. ¿Cuál de las siguientes expresiones matemáticas es una ecuación?

   a. $-y + 1/4 = 15$
   b. $-5 + 2 = -x$
   c. ambas, a y b
   d. ninguna

6. ¿Cuál de las siguientes expresiones matemáticas no es una ecuación?

   a. $3x - 2$
   b. $x = 0$
   c. $-3 = y$
   d. $2a = 10$

7. ¿Cuál de las siguientes expresiones matemáticas es una ecuación?

   a. $x - 5 < 2$
   b. $x + 2 = 5$
   c. ambas a y b
   d. ninguna

8. En la ecuación $-4x + -6 = -26$

   a. el lado izquierdo es mayor que el lado derecho
   b. el lado derecho es mayor que el lado izquierdo
   c. no se sabe la relación
   d. ambos lados son iguales

9. En una ecuación de la forma $ax + b = c$, donde a es un número entero y b es positivo, ¿qué operación se efectúa primero?

   a. suma
   b. resta
   c. ninguna de las dos
   d. cualquiera de las dos

10. La operación a efectuarse primero en una ecuación de la forma $ax + b = c$ depende de:

   a. el signo del número constante
   b. el coeficiente de la variable
   c. el orden de los términos
   d. el orden de las operaciones

11. En una ecuación de la forma $ax + b = c$, donde a es un número entero y b es negativo, ¿qué operación se efectúa primero?

   a. multiplicación
   b. división
   c. ninguna de las dos
   d. cualquiera de las dos

12. La segunda operación a efectuarse al resolver una ecuación de la forma $ax \neq b = c$ depende de:

   a. el signo del número constante
   b. el orden de las operaciones
   c. el orden de los términos
   d. el coeficiente de la variable

13. En la ecuación $5 + x = 1$ el coeficiente de la variable es:

   a. 5
   b. -6
   c. 6
   d. 1

14. En la ecuación $7a - 5 = 12$ el signo del segundo término es:

   a. mayor que cero
   b. menor que cero
   c. igual a cero
   d. no tiene signo

15. En la ecuación $9x + -6 = -15$ el signo del coeficiente de la variable es:

   a. mayor que cero
   b. menor que cero
   c. igual a cero
   d. no tiene signo

16. En las ecuaciones i) $-4 + 3x = 8$ y ii) $3x - 4 = 8$

   a. i < ii
   b. i > ii
   c. i = ii
   d. no se sabe la relación

17. La ecuación 5x + 2 = 7 se puede expresar como:

a. dos veces un número aumentado en cinco es siete
b. dos veces un número multiplicado por cinco es siete
c. cinco aumentado en dos veces un número es siete
d. cinco veces un número incrementado en dos es siete

18. La ecuación 2x - 4 = 8 se puede expresar como:

a. dos multiplicado por un número disminuido en cuatro es ocho
b. dos veces un número incrementado en cuatro es ocho
c. dos veces un número restado de cuatro es ocho
d. dos multiplicado por negativo cuatro es ocho

19. La ecuación "tres veces un número aumentado en seis es nueve" se puede expresar como:

a. 3(n + 6) = 9
b. 3n + 6 = 9
c. 6(n + 3) = 9
d. 3 + 6n = 9

20. La ecuación "diez disminuido en tres veces un número es uno" se puede expresar como:

a. 3n - 10 = 1
b. 10 - (3 + n) = 1
c. 10 - 3n = 1
d. (3 - n) + 10 = 1

21. La solución de la ecuación x + -8 = 12 es:

a. 20
b. -20
c. 4
d. -4

22. La solución de la ecuación 5 - 2x = -3 es:

a. -4
b. 4
c. -1
d. 1

23. La solución de la ecuación -5x + 4 = -21 es:

a. 20
b. 40
c. -5
d. 5

24. La solución de la ecuación -15 = -3x + 3 es:

a. -6
b. 6
c. 4
d. -4

25. Si al resolver una ecuación obtenemos un valor incorrecto:

a. dicho valor no va a satisfacer la ecuación
b. la ecuación será parcialmente cierta
c. los signos de la ecuación deben ser cambiados
d. una de las partes de la ecuación será falsa

26. Si el orden de las operciones es cambiado al resolver una ecuación:

    a. no se afecta la solución de la ecuación
    b. el signo del valor obtenido tiene que ser cambiado
    c. no se puede obtener una solución
    d. el orden de los términos tiene que ser cambiado

27. Si el orden de los términos de una ecuación es cambiado:

    a. la ecuación no se puede resolver en el mismo orden
    b. se altera el orden de las operaciones
    c. el orden de los signos tiene que ser cambiado
    d. ninguna de las anteriores

28. Si todos los términos del lado izquierdo de una ecuación son cambiados al lado derecho y todos los términos del lado derecho son cambiados al lado izquierdo:

    a. los signos de los términos permanecen iguales, pero se altera la ecuación
    b. los signos de los términos se cambian, pero la ecuación permanece igual
    c. no se alteran los signos ni la igualdad
    d. se cambian los signos y la igualdad

APPENDIX B

ATTITUDES INVENTORY TO MEASURE ATTITUDES TOWARD THE SUBJECT

ATTITUDE INVENTORY

Since no student was born with an apparent like or dislike of mathematics and his attitude was developed through personal experiences, it is our contention that such attitudes may be changed. Many of our behavioral objectives and classroom activities are designed to develop positive student attitudes toward mathematics. If a signficant, positive change in attitude can be accomplished, it is often accompanied by a significant increase in student motivation and skills.

CONDUCTING THE ATTITUDE SURVEY

The test should be administered in a pre-post test format. The survey is self-explanatory and the students are instructed not to put their names on the questionnaire. It is extremely important for the students to believe that the questionnaires are anonymous. Once the student places his or her name on such a survey, the researcher may not obtain a reliable attitude measure. However, it is equally important for the researcher to be able to identify individual student responses. For this reason, the attitude surveys are coded thus enabling the research to identify individual student responses. The rationale of this procedure is more easily understood once we examine the statistical method of interpreting the test data.

ANALYZING THE DATA

Once the attitude survey is completed, an average attitude score may be computed for each student. This average score is determined separately for the student's pre-test responses and his post-test responses, thus enabling the researcher to make a comparison.

Each item on the attitude survey is assigned a scale value ranging from 1.0 to 10.5. The more positive the attitude statement, the greater is its corresponding scale value. The scale value for each survey item is listed in the table below:

1. I avoid math because I am not very good with figures. (3.2)

2. Math is very interesting. (8.2)

3. I am afraid of doing word problems. (2.0)

4. I have always been afraid of math. (2.5)

5. Working with numbers is fun. (8.7)

6. I would rather do anything else than do math. (1.0)

7. I like math because it is practical. (7.7)

8. I have never liked math. (1.5)

9. I don´t feel sure of myself in math. (3.7)

10. Sometimes I enjoy the challenge presented by a math problem. (7.0)

11. I am completely indifferent to math. (5.2)

12. I think about math problems outside of school and like to work them out. (9.5)

13. Math thrills me and I like it better than any other subject. (10.5)

14. I like math but I like other subjects just as well. (5.6)

15. I never get tired of working with numbers. (9.8)

To obtain the average attitude score for each student, all items checked by each student are assigned their scale values and a numerical average is computed.

As an example, suppose a student checked items 1, 3, 4, 8, 9 and 14 on his pre-test attitude survey. The sum of the scale values for these six items is 18.5, and their average is 3.08. Therefore, a pre-test average attitude score of 3.08 is recorded for that student. Likewise, assume the student checked items 2, 5, 10, 12 and 14 on the posttest survey. The sum of the scale values for these five items is 39.0, and their average is 7.80. Since the student´s average attitude score increased 3.08 to 7.80, we may assume a positive attitude has been developed. (For some students, their average scores may decrease and thus show the development of a less positive attitude.)

Directions:

Place an "X" in front of any of the following Attitude Statements which you feel apply to you. You may check as many statements as you feel are necessary.

_____1) I avoid math because I am not very good with figures.

_____2) Math is very interesting.

_____3) I am afraid of doing word problems.

_____4) I have always been afraid of math.

_____5) Working with numbers is fun.

_____6) I would like math because it is practical.

_____7) I would rather do anything else than do math.

_____8) I have never liked math.

_____9) I don't feel sure of myself in math.

____10) Sometimes I enjoy the challenge presented by a math problem.

____11) I think about math problems outside of school and like to work them out.

____12) I am completely indifferent to math.

____13) Math thrills me and I like it better than any other subject.

____14) I like math but I like other subjects just as well.

____15) I never get tired of working with numbers.

Escribe una "X" al lado del numero correspondiente a la afirmacion que mejor describe tu actitud hacia las matematicas. Puedes marcar tantas como creas necesarias.

__________1. Rechazo las matematicas porque no soy bueno trabajando con numeros. (3.2)

__________2. La matematica es interesante. (8.2)

__________3. Me da miedo resolver problemas verbales. (2.0)

__________4. Le tengo miedo a las matematicas. (2.5)

__________5. Es divertido trabajar con numeros. (8.7)

__________6. Me gusta la matematica porque es practica. (1.0)

__________7. Prefiero hacer cualquier otra cosa que hacer matematica. (7.7)

__________8. Nunca me han gustado las matematicas. (1.5)

__________9. No me siento aeguro trabajando con las matematicas. (3.7)

__________10. A veces me gusta el reto que presenta un problema de matematica. (7.0)

__________11. Pienso en problemas de matematica fuera de la escuela y trato de hacerlos. (5.2)

__________12. Soy indiferente hacia las matematicas. (9.5)

__________13. Las matematicas me entusiasman y me gustan mas que cualquier otra materia. (10.5)

__________14. Me gustan las matematicas tanto como otras materias. (5.6)

__________15. No me canso de trabajar con numeros. (9.8)

APPENDIX C

LEARNING STYLE INVENTORY

LEARNING STYLE INVENTORY*

This inventory is designed to assess your method of learning. As you take the inventory, give a high rank to these words which best characterize the way you learn and a low rank to the words which are least characteristic of your learning style.

You may find it hard to choose the words that best describe your learning style because there are no right or wrong answers. Different characteristics described in the inventory are equally good. The aim of the inventory is to describe how you learn, not to evaluate your learning ability.

Instructions

There are ten sets of four words listed below. Rank order each set of four words assigning a 4 to the word which best characterizes your learning style; a 3 to the word which next best characterizes your learning style; a 2 to the next most characteristic word, and a 1 to the word which is least characteristic of you as a learner. Be sure to assign a different rank number to each of the four words in each set. Do not make ties.

1.	___involved	___tentative	___discriminating	___practical
2.	___receptive	___impartial	___analytical	___relevant
3.	___feeling	___watching	___thinking	___doing
4.	___accepting	___aware	___evaluative	___risk-taker
5.	___intuitive	___questioning	___logical	___productive
6.	___concrete	___observing	___abstract	___active
7.	___present-oriented	___reflecting	___future-oriented	___pragmatic
8.	___open to new experiences	___perceptive	___intelligent	___compete
9.	___experience	___observation	___conceptualization	___experimentatic
10.	___intense	___reserved	___rational	___responsive

FOR SCORING ONLY

CE__________ RO__________ AC__________ AE__________

*Kolb, Irwin, and McIntyre, Organizational Psychology: An Experimental Approach. Prentice Hall, Inc., 1971.

ESTILOS DE APRENDIZAJE

Instrucciones: Abajo encontraras cuatro listas de palabras. Valora cada palabra desde un valor de cuatro (4) a la palabra que mejor te describa a uno (1) a la que te describe menos.

Completa todas las lineas del 1 al 10.

Ejemplo:

_____alegre	_____sensato	_____preoccupado	_____energico

1.	_____comprometido	_____tentativo	_____preocupado	_____practico
2.	_____receptivo	_____imparcial	_____analitico	_____relevante
3.	_____sintiendo	_____mirando	_____pensando	_____haciendo
4.	_____aceptando	_____consciente	_____evaluado	_____aventurero
5.	_____intuitivo	_____inquisitivo	_____logico	_____productivo
6.	_____concreto	_____observado	_____abstracto	_____activo
7.	_____orientado al presento	_____reflexivo	_____orientado al futuro	_____pragmatico
8.	_____abierto a nuevas experiencias	_____perceptivo	_____inteligente	_____competente
9.	_____experiencia	_____observacion	_____conceptua-lizacion	_____experimenta-lizacion
10.	_____intenso	_____reservado	_____racional	_____responsable

Suma las cuatro columnas.

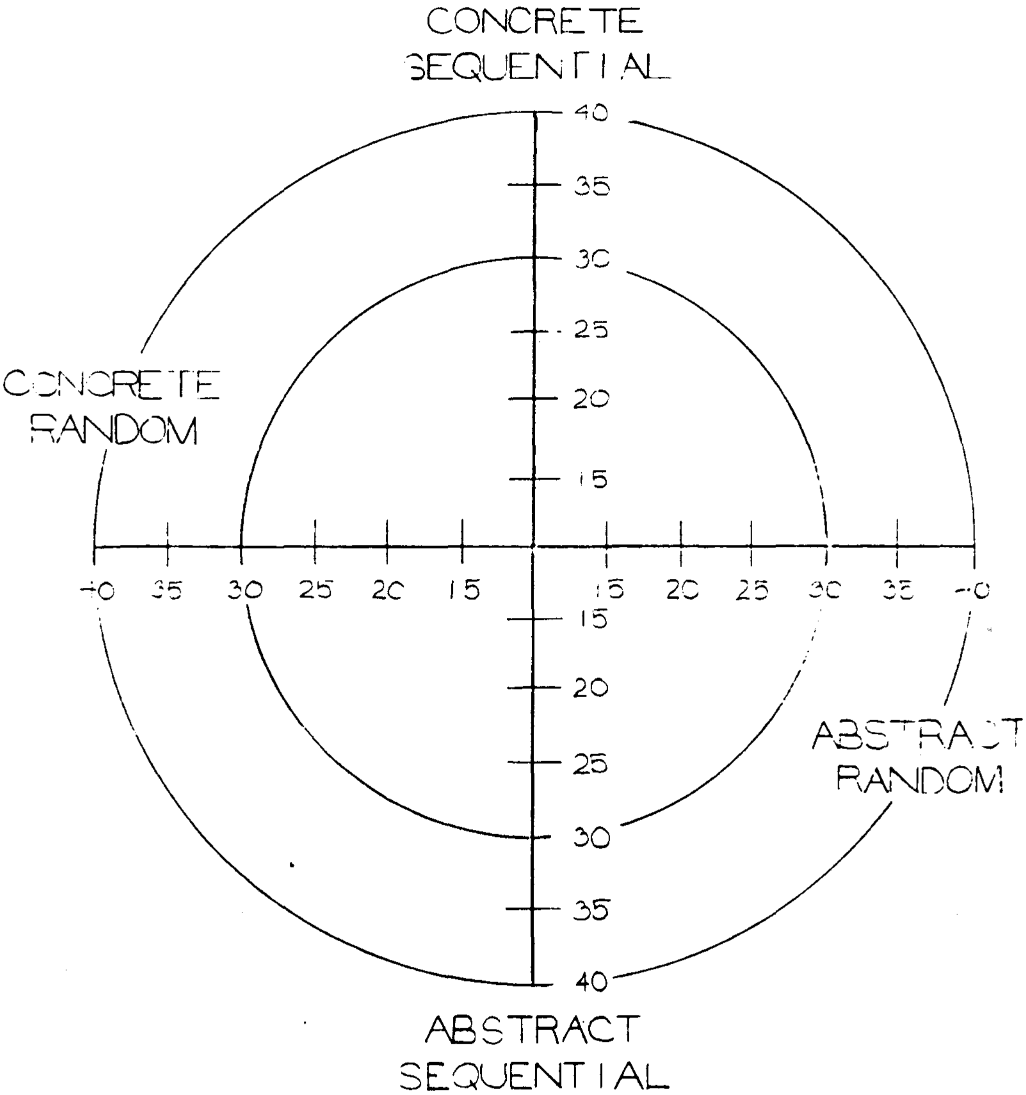
C.S.__________ A.R.__________ A.S.__________ C.R.__________

Tomado de: Kolb, Irwin and McInteyre - Organizational Psychology: An Experimental Approach.

APPENDIX D

INFORMATION ACQUISITION PREFERENCE PROFILE

INFORMATION ACQUISITION PREFERENCE PROFILE
(IAP)



APPENDIX E

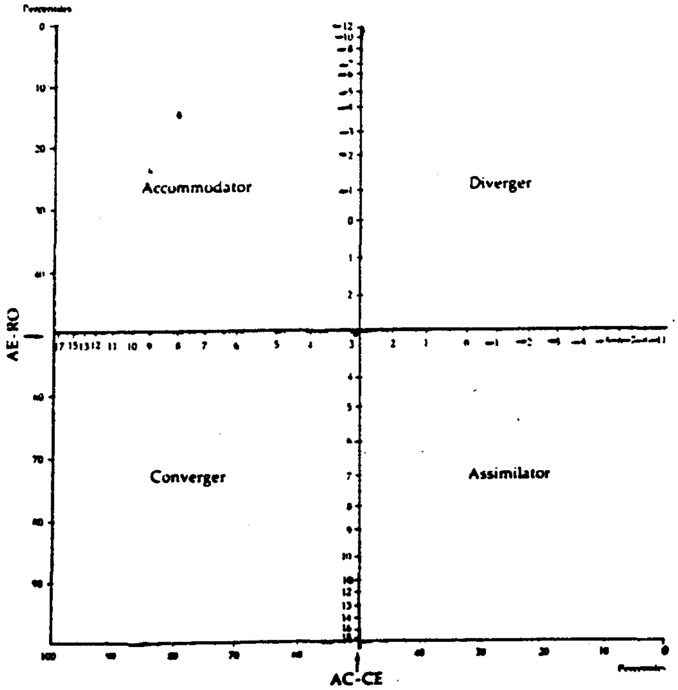
THE LEARNING STYLE TYPE GRID

Identifying Your Learning Style Type

Each person's learning style is a combination of the four basic learning modes. It is therefore more meaningful to describe your learning style by a single data point that combines your scores on the four basic modes. This is accomplished by using the two combination scores, AC-CE and AE-RO. These scales indicate the degree to which you emphasize abstractness over concreteness and action over reflection, respectively.

The grid below has the raw scores for these two scales on the crossed lines (AC-CE on the vertical and AE-RO on the horizontal) and percentile scores based on the normative group on the sides. By marking your raw scores on the two lines and plotting their point of interception you can find which of the four learning style quadrants you fall into. These four quadrants, labelled Accommodator, Diverger, Converger, and Assimilator, represent the four dominant learning styles. If your AC-CE score were -4 and your AE-RO score were +8, you would fall strongly in the Accommodator quadrant. An AC-CE score of +4 and an AE-RO score of +3 would put you only slightly in the Converger quadrant. The closer your data point is to the point where the lines cross the more balanced is your learning style. If your data point is close to any one of the four corners, this indicates that you rely heavily on one particular learning style.

LEARNING STYLE TYPE GRID



"Y ASI, ESPERANDO CON LARGURA DE ANIMO, ALCANZO LA PROMESA

Hebroes 6:15

APPROVAL SHEET

The dissertation submitted by José Rodríguez has been read and approved by the following committee:

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

4/18/85
Date

Todd Hoover
Director's Signature