THE UNIVERSITY OF MANITOBA

COMPUTER ASSISTED LEARNING WITH STUDENTS WHO ARE DEAF

by

LOUIS C. REEVES

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ABSTRACT

This study investigated the efficacy of computer assisted learning (C.A.L.) in language arts and mathematics with students who were severely or profoundly deaf. Three groups of students were assigned by their class groupings to one of three experimental conditions: C.A.L. language arts group; C.A.L. mathematics group; or the C.A.L. combined language arts and mathematics group. All three groups received regular classroom instruction in language arts and mathematics. According to the treatment condition, each group received C.A.L. either in language arts or mathematics or both language and mathematics for six months, two or three times each six day school cycle. The subjects were administered the Stanford Achievement Test (S.A.T.) before (pretest 1 and pretest 2), after (post test) and three weeks after (retention test) the treatment period.

The results of this study showed that there was a significant difference over time. However, the results did not reveal statistical significance among the three treatment groups. Any statistical significance that was obtained was confounded by two factors: the selection of biased treatment groups; and the use of different alternate forms of the S.A.T. (1964). Therefore, it was not possible to derive any meaningful generalizations, or to predict any trends from the experimental data.

Although statistical significance was not obtained in this study, several important observations were noted which have relevant

educational implications. Severely and profoundly deaf students were able to work independently at the computer terminal; and C.A.L. can be a practical means of reinforcing the academic skills of deaf students.

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CHAPTER I

INTRODUCTION

During the past decade, considerable research has accumulated which suggests that Computer Assisted Learning (C.A.L.) has the potential to serve as a useful instructional tool to supplement traditional classroom instruction. Three major factors have made computers increasingly available as instructional devices within many school systems: the development of programmed instruction (P.I.), the rapid growth of minaturized electronic components, and reduced computer hardware costs. Computer technology has long been an ally of industry, but only recently has the field of education realized its versatility and rich potential.

One of the goals of education is to focus on the individual needs of students. C.A.L. has the capability to provide a program of individualized instruction. Since the mid 1960's, P.I. and C.A.L. have been used successfully to individualize instruction in the public elementary and secondary schools and in universities. Recent research suggests that P.I. and C.A.L. could be used to tailor instructional materials to meet the specific needs of exceptional children in special education. It would appear that a practical use of C.A.L. could be with exceptional children who need the additional instruction and remediation that computers may provide. Thus it seems feasible that C.A.L. may help to improve the educational achievement of students who are deaf.

The National Advisory Committee on Education of the Deaf has established that an individualized program of instruction is one of the basic rights to which all deaf persons are entitled (Withrow, 1973, p. 405). Surveys suggest, however, that many deaf educators persist in using traditional teaching methods and materials developed for hearing children. Current studies of academic achievement of the deaf would seem to indicate that the continued use of these methods and materials will perpetuate the disproportionate number of underachieving young deaf adults who graduate from schools and classes for the deaf each year. It is incumbent that educators of the deaf continue to search for innovative methods and techniques to help improve the academic competencies of deaf students.

C.A.L. is one such innovative method that may optimize the learning process. The computer may have significant implications for deaf education in that it provides a non-oral, visual approach to learning. The high motivational level that may result from the computer's self-instructional process further suggests that the computer may be a valuable adjunct of instruction for deaf children. The computer may enrich the teaching process as well as offer unique learning opportunities for individual deaf children.

P.I. has been used successfully in the past with deaf students in both the mathematics and language arts areas. Research with C.A.L. suggests that deaf students can be taught computational skills with the computer. Although favorable results with C.A.L. have been obtained in the language arts area, further research is required to demonstrate its efficacy. The results and implications of previous research that used C.A.L. with deaf students, will be used as a frame of reference for the present investigation.

The development of a C.A.L. environment poses certain problems that need to be resolved before it can be instituted in a school for the deaf:

1. Deaf students must be taught to manipulate the controls of a computer terminal, especially the telephone, effectively and independently.
2. Young deaf students must be trained over many sessions before they can be expected to use the computer terminal independently.
3. Appropriate and sufficient numbers of programs must be available to accomodate the diverse needs of deaf students.

The present study specifically will research the following questions:

1. can drill and practice programs in mathematics and language arts effectively reinforce skills which have been previously taught in the classroom; and
2. can C.A.L. help deaf students to retain these skills over a period of time?

It is the thesis of this study that C.A.L. can be both a practical and effective means to enhance the academic skills of students who are deaf.

CHAPTER II

THE DEAF STUDENT

An Introduction to Deafness

Deafness and its resultant effects may be compared to an iceberg (Brill, 1969, p. 8). The most obvious effect is the deaf person's inability to talk normally and to understand the speech of other people. The more serious problems, such as poor educational achievement and psycho-social maladjustment, are not easily observed. The main effect of deafness is the person's inability to develop normal communication patterns. This communication handicap is the general basis from which other serious problems develop.

Deafness is more than just a number on the decibel scale that describes the severity of a hearing loss. In addition to the language difficulties, the effects of deafness vary among individuals, which makes it difficult to define the term precisely. In order to plan an effective educational program for deaf students, it is necessary to understand the factors which influence their psychological, social and emotional development, and their educational achievements. The purpose of this section will be to define deafness educationally, to classify the causes and types of deafness, and to summarize other significant characteristics that affect the educational achievement of deaf students.

Definitions and Classification Systems

In 1975, the Conference of Executives of American Schools for the Deaf (CEASD) adopted new definitions of the terms "hearing impairment", "deaf", and "hard of hearing" (Proceedings of CEASD, 1975, pp. 25-28):

1. Hearing Impairment

   This is a generic term indicating a hearing disability which may range in severity from mild to profound. This term includes the subsets of "deaf" and "hard of hearing".

2. Deaf

   A deaf person is one whose hearing disability precludes successful processing of linguistic information through audition, with or without a hearing aid.

3. Hard of Hearing

   A hard of hearing person is one who, with the use of a hearing aid, generally has residual hearing sufficient to enable successful processing of linguistic information.

In the last decade a plethora of articles and research has been disseminated in the field of deaf education. Some of the terms used can have different meanings depending upon one's perspective and/or philosophy of deaf education. In order to clarify these terms, the CEASD (1975, pp. 26-28) included in its definition a description of these troublesome terms:

1. <u>Disability</u>

   Hearing disability refers to the partial or total incapacity to hear sounds due to an impairment of the auditory system.

2. <u>Impairment</u>

   Hearing impairment refers to the physical malformation or alteration of the auditory system that produces a hearing disability.

3. <u>Handicap</u>

   A handicap, as related to deafness, exists only to the extent to which the disability limits the overall functioning.

Any definition or classification of deafness must include four basic factors: the degree of impairment, the age at onset of impairment, the cause, and the physical origin of the impairment. The first two factors are of critical importance to educators of the deaf.

I. The Degree of Impairment

Hearing impairment is generally classified according to the level of functional or residual hearing. In 1965 the Committee on Conservation of Hearing of the American Academy of Opthalmology and Otolaryngology divided hearing loss into categories of severity of handicap based on pure tone audiometric tests (Table 1). Specifically, each class is defined in terms of the average hearing threshold level

TABLE 1

CLASSES OF HEARING HANDICAP

Hearing Threshold Level (dB - ISO)	Degree of Handicap	Ability to Understand Speech
0 - 25	Normal	No significant difficulty with faint speech
25 - 40	Slight	Difficulty with faint speech
40 - 55	Moderate	Frequent difficulty with normal speech
55 - 70	Moderate-Severe	Conversation must be directed at the person
70 - 90	Severe	Speech cannot be learned by conventional means
90 and above	Profound	With amplification the person only perceives vibrations and not complete sound patterns

SOURCE: Adapted from Davis and Silverman (1970).

in the better ear across the speech frequencies of 500, 1,000, and 2,000 hertz (Hz) in terms of decibels (dB) as measured by a pure tone audiometer (Davis and Silverman, 1970, pp. 254-55). Although these divisions are arbitrary, they are useful as a general guide of the degree of severity of hearing losses. Generally, they are indicative of the student's ability to understand oral speech, and they suggest special provisions that are necessary for the individual with a hearing impairment to comprehend speech. Although these categories are widely used by educators of the deaf, they have limited usefulness in describing a person's handicap if this is the sole means of classification.

The CEASD (1975, pp. 26-27) developed four similar levels of hearing loss based on the degree of impairment in decibels (Table 2). Each level is accompanied by an interpretation of its effects on communication and language development; and its implications for the educational placement of hard of hearing and deaf students. The CEASD recommends that these levels be used in research that study optional educational settings and communication methodologies used in the education of deaf and hard of hearing students.

II. The Age of Onset of Hearing Loss

Deafness may also be categorized on the basis of onset (CEASD, 1975, p. 26), which is particularly relevant to the degree of language handicap that may result:

1. Prelingual Deafness

Prelingual deafness is present at birth or occurs at an

TABLE 2

LEVELS OF HEARING IMPAIRMENT

Hearing Threshold Levels (ISO)	Probable impact on Communication and Language	Implications for Educational Settings	
		Type	Probable Need
Level I: 26-54 dB.	Mild	Full Integration[1]	Most Frequent
		Partial Integration[2]	Frequent
		Self-Contained[3]	Infrequent
Level II: 55-69 dB.	Moderate	Full Integration	Frequent
		Partial Integration	Most Frequent
		Self-Contained	Infrequent
Level III: 70-89 dB.	Severe	Full Integration	Infrequent
		Partial Integration	Most Frequent
		Self-Contained	Frequent
Level IV: 90 dB and above	Profound	Full Integration	Infrequent
		Partial Integration	Frequent
		Self-Contained	Most Frequent

1. Full integration means total integration into regular classes for hearing students with special support services.

2. Partial integration means taking all classes in a regular school, some on an integrated basis and some on a self-contained basis.

3. Self-Contained means attending classes exclusively with other deaf and/or hard of hearing classmates in regular schools, special day schools or special residential schools.

SOURCE: Proceedings of Conference of Executives of American Schools for the Deaf (1975).

early age prior to the development of speech or language. Prelingual deafness poses a much more serious educational problem because of its effects on language acquisition.

2. Postlingual Deafness

Postlingual deafness occurs at an age following the development of speech and language.

Recent research (Gentile and Rambin, 1973; Rawlings, 1973; and Jensema and Mullins, 1974) estimates that as many as two-thirds of deaf students whose age of onset is known, are hearing impaired from birth. They further estimate that 80 to 90 percent of the students in programs for the hearing impaired in the United States, acquire their hearing loss by the time they are three years old. In addition, Rawlings' (1973, p. 8) research indicates that there is a trend for students who are prelingually deaf to have more severe losses than those who are postlingually deaf. Thus, the overwhelming majority of hearing impaired students enrolled in special educational programs are prelingually deaf.

III. The Primary Causes of Deafness

In recent years, educators have shown increased interest and concern in the relationship between etiologies of deafness and their influence on learning and behavior. Research indicates that a significant amount of the behavioral and educational variance among deaf persons cannot be attributed solely to the severity of hearing loss. Rather this can be better understood in terms of the causes of deafness (Vernon, 1969). Therefore, it is necessary to discuss briefly the primary causes of deafness to appreciate the significance of their effects on the potential educational achievement of deaf students.

The reported causes of hearing loss are categorized into two groups, pre-natal causes and post-natal causes. However, often it is not possible to determine the cause of deafness. For example, research indicates that approximately 25 to 48 percent of deaf students report no known cause of their deafness (Vernon, 1969; Rawlings, 1973; and Jensema and Mullins, 1974). The most recent surveys by Rawlings (1973) and Jensema and Mullins (1974) state that of students whose cause of deafness is known, approximately two-thirds report a pre-natal cause.

Maternal rubella is a frequently reported pre-natal cause of hearing loss. It is the cause of deafness for 15 to 20 percent of students who report a known cause of deafness. Epidemics of rubella are cyclical; the most severe outbreak occurring in 1964-65. Calvert (1969) estimates that during this epidemic, approximately 6,000 American children were born with hearing losses so severe that they would require special educational intervention. Jensema (1974, pp. 703-05) reports that, as a group, rubella-deafened children exhibit certain characteristic traits. They have a more severe hearing loss than children with other causes, and they have a higher frequency of multiple handicaps, especially visual, emotional/behavioral, and heart-related disorders. As a result of their severe hearing loss and additional handicaps, a high proportion of rubella-deafened children are enrolled in special programs for the multihandicapped deaf.

Vernon (1969) researched the effects of five major etiologies of deafness: heredity, Rh factor, prematurity, meningitis, and rubella on the intellectual, educational, psychological, and behavioral development of deaf children. The results of his study reveal that many secondary disabilities, such as expressive and receptive communication disorders, mental deficiency, atypical behaviour, and learning problems are caused by brain damage which results from the same condition that causes deafness. Vernon (1969, p. 111) notes that this may be reflected in a population of less academically capable students.

In the last thirty years, there has been an important change in the major etiologies of deafness. Brill (1961, pp. 168-75) reports that prior to the advent of antibiotics in the 1940's, as many as 40 to 45 percent of deaf students were adventitiously deaf and a large proportion of these students were postlingually deaf. Now, however, approximately 90 percent of deaf students have become deaf by the age of three, and thus, they are prelingually deaf. The majority of these students begin school with minimal speech and language development. This situation indicates why curricula and methods must necessarily change to meet the needs of deaf students today.

IV. The Physical Origins of Deafness

Deafness may also be classified according to the area of impairment in the auditory system. This classification system is most important for purposes of medical management. From the educational perspective, it is important to know the area of impairment to determine the audiological needs of the individual. There are three main types of hearing loss:

1. Conductive Deafness

   Conductive deafness is an impairment caused by conditions in the outer ear, middle ear, or Eustachian tubes which interfere with the passage of sound waves to the inner ear. Generally, an individual with a conductive hearing loss has the same loss of sensitivity for sounds of all frequencies. The hearing in conductive losses usually can be improved or restored by medical or surgical treatment.

2. Sensorineural Deafness

   Sensorineural deafness is an impairment due to some pathology in the inner ear or along the neural pathway from the inner ear to the brain stem. Most people born with hearing losses have sensorineural deafness (Newby, 1970, p. 50). Typically, a person with sensorineural hearing loss has better hearing for the lower frequencies than for the high frequencies. Sensorineural hearing losses generally cannot be helped through treatment. Once the nerve fibers are destroyed, there is no regeneration possible. The majority of deaf students in schools for the deaf have sensorineural hearing losses.

3. Mixed Hearing Losses

Occasionally persons may exhibit symptoms of both conductive and sensorineural hearing losses. In such cases, the conductive hearing loss component may be treated medically, and the individual may be left with only a sensorineural hearing loss.

How Amplification (Hearing Aids) May Help A Hearing Loss

A hearing aid is an instrument that brings sound more effectively to the person's ear, primarily by making it louder. Its primary purpose is to make speech intelligible for the listener; however, no hearing aid can ever compensate completely for a hearing loss (Davis and Silverman, 1970, p. 305). Although a hearing aid raises the intensity of sound delivered to the ear, this does not necessarily imply that the person will be able to discriminate the speech sounds that he hears. Often parents regard hearing aids as a panacea, and come to believe that their child will be able to hear and learn to speak as a result of wearing hearing aids. Mindel and Vernon (1971, p. 34) state emphatically that, "In no instance will sound awareness insure that a deaf child will have normal speech".

Residual hearing refers to the hearing available, after damage to the auditory mechanism has occurred. Many authorities contend that relatively few hearing impaired children are totally deaf; that is, the majority of them have some residual hearing. Ling (1976, p. 16) reports that many studies indicate that the more residual hearing a child has and uses, with amplification, the more natural his speech probably will be. Some authorities in aural rehabilitation (Sanders, 1971; and Ling, 1976) maintain that even profoundly deaf persons with sensorineural hearing losses can benefit from using hearing aids because they have some residual hearing which is educationally useful.

Mindel and Vernon (1971, p. 34) however, categorize residual hearing as being either "functionally useful remnants of hearing in the higher pitched ranges" or as "useless sensitivity to low-pitched sounds". Consonant sounds, which carry the information of speech, are heard as high frequency sounds; while vowel sounds are heard as low frequency sounds. Thus, the potential for learning speech through the amplification of residual hearing, depends upon the kind and extent of residual hearing. The majority of profoundly deaf children have little measurable residual hearing in the high frequency ranges; and consequently, are rarely able to develop normal speech and language solely through amplification and the use of residual hearing. Sanders (1971, p. 204) and Ling (1976, p. 17) acknowledge that the amplification of residual hearing should be a part of a multisensory approach in the education of profoundly deaf children.

It is almost impossible to derive a set of criteria to determine who should wear a hearing aid. In all cases, both the degree of the hearing loss and the configuration of the hearing loss through the speech frequencies must be considered. Persons with a mild or moderate conductive hearing loss will benefit the most from the use of a hearing aid. Amplification of sound will help them in their speech production and language development. Amplification probably will not influence the speech production and language development of persons with profound, sensorineural hearing losses. As previously mentioned, these individuals constitute the majority of students in schools for the deaf. Through the use of amplification and auditory training, however, profoundly deaf students can be taught to discriminate gross environmental sounds.

Behavioral Characteristics of Deaf Students

I. Intellectual Development

During the past fifty years, there has been extensive research to determine if deaf people differ significantly from normal hearing people in intellectual development. It was assumed that because of their perceptual handicap, deaf persons had altered thought processes that set them apart from normal hearing people (Myklebust, 1964; and Fusfeld, 1967).

Early research concluded that deaf people were poor in concept formation and abstract thinking. This research is considered to be invalid since the tests were tests of deaf persons' verbal skills rather than intelligence tests.

When nonverbal and performance type intelligence tests are used, deaf people closely approximate the norms of the hearing population (Vernon, 1968). Mindel and Vernon (1971, pp. 87-90) have summarized over fifty independent research studies, and the results of these studies indicate that the deaf and hearing populations generally have the same distribution of intelligence. Mindel and Vernon (1971, p. 87) conclude that, "All the available evidence demonstrates that there is no direct relationship between hearing loss and intelligence".

Using Piaget's theories of cognitive development, Furth (1973) has studied the intellectual functioning of deaf children and adolescents. His studies indicate that at the stage of formal thinking, deaf children exhibit a less mature style of thinking. Furth states that this is not directly related to their lack of language. Rather he attributes it to an impoverished environment which does not challenge deaf children as they develop, especially during their school years.

Intelligence tests that are given to deaf persons will be valid only if they are administered by persons who are knowledgeable about deafness and who can communicate with deaf people. Otherwise the results will be invalid, since there will be a greater probability that deaf children will obtain unreliable scores.

II. Educational Achievement

In the last thirty years, there has been extensive research on the educational achievement of deaf students. Vast sums of money have been spent to research what knowledgeable teachers in deaf education already know; namely, that in comparison to their hearing peers, the majority of deaf students in special schools and classes are woefully undereducated. Moores (1970, pp. 37-38) has best summarized this bleak situation:

> ...It has been demonstrated consistently that the educational attainment of deaf children falls far below what might be predicted on the basis of chronological age and/or mental development. A cummulative deficit also has been shown to exist; that is, the academic retardation of the deaf, relative to the hearing, increases as a function of age, due to the tendency for the achievement scores of the deaf to plateau during adolescence. After a deaf child enters his teens, annual gains are typically measured in terms of tenths of years. The deaf child starts school at a disadvantage which is continually expanding and is never overcome.

Current studies of the academic achievement of deaf students indicate that their lowest scores are earned on the language and reading subtests, and that they obtain relatively higher scores on low language academic areas, such as Arithmetic Computation (see Appendices A and B). As a result of their language deficit, deaf students do the best in those academic subjects that do not require high reading levels.

Research by Moores and Quigley (1969) points out that even these low scores are spuriously inflated, since the achievement tests, which are standardized on a hearing population in regular public schools, assume a base of language proficiency which most deaf students do not possess.

Recent analysis of achievement testing has revealed strong relationships between test scores and certain variables (Jensema, 1975):

1. High scaled scores (which eliminate the age factor) are obtained by deaf students: (a) whose hearing

loss occurred after the age of three; (b) who have an inherited hearing loss; or (c) who spend less time in special educational programs.

2. Low scaled scores are obtained by deaf students who: (a) have progressively more severe hearing losses; and (b) in addition to their deafness have an additional handicapping condition(s).

It must be noted, however, that these results do not include the achievement of the growing numbers of deaf students who are successfully integrated into regular educational programs. McConnell (1973, p. 379) maintains that without these results, an accurate assessment of the educational achievement of deaf students is not demonstrated.

In summary, research results clearly indicate that the majority of deaf students, who have been in special educational programs for approximately twelve years, are functionally illiterate and lack basic linguistic skills. These results reveal how normal learning is significantly impeded by severe and profound hearing losses. But Mindel and Vernon (1971, p. 94) also attribute this meagre educational attainment to educational systems "which have failed to develop the intellectual potential of the average deaf persons".

III. Language Development

The most serious effect of a profound, prelingual hearing loss, is the deaf child's inability to develop competent linguistic skills. The resulting language deficit has a pervading influence on the deaf child's educational attainment. Despite intensive efforts by educators, improved methods, and innovative techniques of teaching, there has been no significant improvement in the encoding and decoding linguistic abilities of deaf students.

Research on the development of language in normal children suggests that there is a critical period for language acquisition. These language-formative years appear to be between birth and age five (McNeill, 1966; Moores, 1970; and Mindel and Vernon, 1971). If proper language stimulation does not occur during this optimal period, then language development may be severely retarded. Lenneberg (1967) suggests that this special capacity to acquire language may disappear with the beginning of adolescence. This suggests that any experiential deprivation during these critical years for language learning may be irreversible in effect (Alterman, 1970, pp. 518-19).

Although grammatical speech does not begin before one and a half years of age (McNeill, 1966, p. 22), it is estimated that by age five, a hearing child has a vocabulary of 8,000 to 20,000 words. Research indicates that five and six year old children use all the basic sentence patterns of English in their speech (Loban, 1963; as reported in Smith, Goodman and Meredith, 1970, pp. 9-10). By age five, the normal child is fluent in his native language, and he continues to refine his grammar until by age ten his mastery is equivalent to that of adults (C. Chomsky, 1969; as reported in Kennedy, 1972, p. 1). Thus, in an extremely short period of time, a child has developed the foundation for language competence. As the child's language develops, it becomes a tool whereby he derives meaning from the world around him.

The language development of the prelingually, profoundly deaf child stands in sharp contrast to that of the normal hearing child's. It is extremely difficult to obtain an accurate measure of the receptive and expressive vocabulary of very young profoundly deaf children. These children may communicate by using gestures, oral speech, speechreading, audition, fingerspelling, signing, and reading, either singly or in various combinations. It is probably for this reason that the writer has been unable to find in the literature any recorded estimates of the vocabulary development of young deaf children. It is this writer's opinion, however, that it is not uncommon that many young deaf children begin school with an expressive vocabulary of less than one hundred words, regardless of their method of communication. A. van Uden (1970, p. 525) suggests that with intensive parent home training and auditory training, deaf children can develop a spoken vocabulary of 300 words by age five. It is generally agreed that deaf children, at age six, have little or no functional knowledge of sentence structure.

According to McNeill (1966, pp. 5-6) all children have an innate capacity to acquire language. N. Chomsky (1968) states that appropriate experiences are required to trigger the language processes into operation. Exposure to the language environment in the home is usually sufficient for the normal child. The profoundly deaf child requires specialized language teaching to compensate for the absence of auditory input. Several methods, that reflect the prevailing theory of grammar, have been developed to teach language to deaf children: the Wing Symbols (1880); the Barry Five Slate (1889); the Fitzgerald Key (1926); and the Natural Approach (1958). A detailed account of these language methods is provided by Miller (1964). The most recent method to appear is the Rhode Island Language Curriculum (1968) which is based on transformational generative grammar. Current achievement results suggests that educators of the deaf still do not have the appropriate method(s) to help profoundly deaf children acquire mature linguistic skills.

The majority of deaf children do not develop a formal method of communication until they begin school. The main exception are deaf children born to deaf parents who begin to use manual communication with their children at a very early age. Without a formal means of communication, the critical years for language acquisition for the majority of deaf students are irretrievably lost. Moores (1970, p. 43) states: "perhaps any language program that is initiated after the age of five, no matter what methods are used, is doomed to failure for the majority of deaf children". In view of the critical years for language acquisition, it is imperative that deaf children be exposed to language as soon as their hearing loss has been diagnosed. A lack of effective communication during these formative years may have significant implications for the child's future development.

IV. Methods of Communication

The development of communication is the most important objective in the education of deaf children. A recent survey by Jordan, Gustason, and Rosen (1976) indicates that the oral/aural method, the Rochester method, and total communication are the three communication methods which are most widely used in classes and schools for the hearing impaired. In order to ensure clarity of discussion, these three methods are defined as follows:

1. Oral/Aural Method

   This is a method of instruction which relies on speech, speechreading, amplification of residual hearing, reading and writing. In its purest form, manual communication is not permitted.

2. Rochester Method

   This is a method of instruction that uses fingerspelling simultaneously with speech, speechreading, and amplification. This method does not permit any other form of communication.

3. Total Communication

   Total communication is an eclectic method of instruction that incorporates aural, manual, and oral modes of communication.

It should be noted that each of these three communication methods is commonly regarded as a philosophy of deaf education, which then is incorporated in the classroom as a method of instruction. In addition, the Rochester method and total communication are to be distinguished from manual methods of communication that are used by the majority of deaf people in their conversation with one another.

The following definitions of the different forms of manual communication are adapted from Fant (1974, pp. 189-97) and Brasel and Quigley (1975, pp. 1-4):

1. Manual Communication

   Manual Communication is the generic term used to represent the language of signs, fingerspelling and structural pantomime. The term encompasses all variations in the language of signs from grammatically structured Manual English to the unstructured American Sign Language.

2. Manual English

   Manual English is a combination of signs and finger-spelling which attempts to adhere to grammatical English syntax. The signed and fingerspelled words of the message generally bear a one-to-one relationship with the same message when spoken verbally. Recently, several similar Manual English systems have been developed in an attempt to teach grammatical English to deaf children. These systems, which are commonly referred to by their acronyms are: SEE, Signing Exact English; SEE, Seeing Essential English; and VE or LOVE, the Linguistics of Visual English.

3. American Sign Language

   American Sign Language is the typical language deaf

> people use when conversing with each other. It is often referred to as ASL or "Ameslan". Some consider it to be a language in itself because it has a unique grammatical structure (Fant, 1971; and Stokoe, 1960; as reported in Brasel and Quigley, 1975, p. 2). Fant (1974, pp. 195-96) maintains that "Ameslan" is the first language for the majority of deaf people, since it is the language with which they are most comfortable and fluent; and English is their second language.

Since the 18th century, deaf education has been confronted with the oral-manual communication controversy. The debate, now, as then, is between proponents of the oral philosophy, who maintain that deaf children must be taught by only oral/aural means, and those who believe that oralism should be supplemented with other techniques, notably fingerspelling and/or sign language. Those who support the oral philosophy believe that the majority of deaf children can be taught to speak and to comprehend spoken language through intensive training in lipreading and auditory training. They feel that any form of manual communication will hinder or prevent development of the child's ability to speak and lipread. Their philosophy rests on the belief that training in speech and speechreading ensures an easier adjustment to the world in which speech is the chief medium of communication (Miller, 1970, pp. 216-17).

Advocates of total communication point out that many deaf children are not able to develop good speech and lipreading skills, and many are not able to develop these skills at all. They regard the fingerspelling and sign language components of total communication as a necessary prerequisite for successful communication. Their position is based on the law of individual differences; that is, since not all deaf children are able to learn speech or speechreading equally well, the means of communication used to teach them should match their abilities (Brill, 1974, pp. 257-60). For many deaf children, total communication becomes the preferred mode of communication through which knowledge of language and other subject areas can be developed. Despite basic differences in philosophies, both groups have similar long-range educational goals: improvement in speech perception, academic ability, language skills, and psychological well-being (Simmons-Martin, 1972, p. 549).

The tragedy of the debate between oralism and total communication is that it has often forced educators to defend their teaching methods (Kennedy, 1972, p. 10). Historically, the defense of either philosophy has been based on rhetoric and emotion rather than on the results of empirical research. Although recent research tends to support the claim that educational achievement is enhanced through the use of total communication (Vernon and Koh, 1970, 1971; and Moores, Weiss, and Goodwin, 1974) there is some current research which suggests that the efficacy of any one method is not conclusive (White and Stevenson, 1975; and Beckmeyer, 1976).

Summary

The information presented herein suggests that there is a myriad of complex factors that have a profound influence on the education of children who are deaf. It is readily apparent that if educators are to assist deaf children to attain their maximum potential in their psychological, social, emotional, and academic development, then it is incumbent that educators plan individualized programs that will best meet the individual needs of their students.

CHAPTER III

A REVIEW OF INDIVIDUALIZED INSTRUCTIONAL TECHNIQUES WITH EXCEPTIONAL CHILDREN

INTRODUCTION TO PROGRAMMED INSTRUCTION AND COMPUTER ASSISTED LEARNING

The underlying principles of Computer Assisted Learning (C.A.L.) are found in Programmed Instruction (P.I.). The features and advantages of C.A.L. are similar to those provided by P.I. Research suggests that both P.I. and C.A.L. are effective methods that facilitate the learning of academic and social skills by both regular and special education students.

Modern developments in P.I. begin with the work of Dr. S. L. Pressey in the 1920's. Dr. Pressey developed machines that could teach and test by using multiple choice questions. Dr. Pressey's work met with little support until the 1960's. Then, renewed interest in P.I. developed with the work of B. F. Skinner's "linear programming" and Norman Crowder's "branching programming". Following their work, the use of P.I. exploded as countless numbers of business, educational, industrial and military organizations utilized P.I. via the teaching machine. Much of this initial enthusiasm diminished, however, when it was discovered that the teaching machine was not the panacea it was anticipated to be. Since these beginnings, much experimentation, adaptation, and refinement have continued with the result that now P.I. has gained acceptance in education in both written and machine form.

P.I. is a direct application of learning theory provided by theorists on human learning to instructional procedures. Pressey (1967), "the father of teaching machines", defines P.I. simply as planned instruction. Pfau (1970, pp. 344) states that P.I. is concerned with the precise selection and arrangement of subject matter so that the student is able to move from entry level to mastery level in the most efficient manner. According to Green (1962, p. 111) the basic paradigm of P.I. is the interaction between the pupil and the programmer. The most important characteristic of this interaction is that reinforcement of one person's behavior depends upon the action of another person for its mediation. Deterline (1962, pp. 4-5) states that the identifying characteristic of P.I., in both book and machine form, is the active role assigned to the student. Active responding refers to thinking, verbalizing at an intellectual level, and reacting to the subject matter. Other characteristics of P.I. include the sequential presentation of small steps, immediate feedback, self-pacing, and high probability of correct responses.

The concept of C.A.L. is based on the principles of P.I. and individualized learning. Although there is a forty year history of computer technology, computers were not installed in school systems until the 1960's. Since that time, the use of C.A.L. has increased to the extent that it has ceased to be a novelty on the educational scene. It has been demonstrated to be a technologically feasible tool in the teaching/learning process (Taylor et al., 1974, p. 1). Atkinson and Wilson (1969, p. 3) attribute this rapid growth of C.A.L. to the rich potential of C.A.L. to answer today's most pressing need in education--the individualization of instruction.

The computer, with its attributes of speed in problem solving, virtually endless storage and retrieval capacity for enormous numbers of facts, and its system of logical ordering of information, seems naturally suited to the educational process. There are various applications of computers in education, for example, C.A.L., Computer Managed Instruction (C.M.I.), Computer Supported Instruction (C.S.I.), Computer Administered Testing and the teaching of computer science. There are indications that the use of computers in education will continue to expand in type, number and importance. A recent survey indicates that 26% of all secondary schools in the United States now use computers specifically for instructional purposes (vonFeldt, 1977, pp. 2-3). It has been predicted that within five to ten years, practically all high school and college students will be using a computer daily (Piecewicz, 1977, p. 15).

C.A.L., as used in this study, is defined as: "A man-machine interaction in which the teaching function is accomplished by a computer system without intervention by a human instructor. Both training material and instructional logic are stored in computer memory" (Salisbury, 1971, p. 48). Taylor et al. succinctly define Computer Assisted Instruction (C.A.I.) which is synonymous with C.A.L., as "the use of the computer for direct instruction of students" (Taylor et al., 1974, p. 2).

Within the context of C.A.L., there are three basic modes of instruction which are defined by Taylor et al. (1974, pp. 3-21) as:

1. Drill and Practice

   The drill and practice mode of C.A.L. involves the use of the computer to drill students in facts or to assist the student in practicing skills. With drill and practice, facts or skills are taught through some other mode or means. The students then use C.A.L. drill and practice to memorize those facts or to practice those skills.

2. Tutorial

   The tutorial mode of C.A.L. is intended to approximate the interaction which would occur between a skilled, patient tutor and an individual pupil. A tutorial system is used initially to present a concept and to develop a student's skill in using the concept.

3. Simulation

   In this mode of computer use, the learner is led by the computer through a learning situation similar to actual on-the-spot learning, as if the learner were in the real-life situation. The model of reality may represent an economic system, a social system, a set of physical relationships etc. In using the simulation the students learn the structure of the system, the relationships and assumptions operating, and have an opportunity to test and refine decision strategies.

Advantages of C.A.L.

Majer (1972, pp. 86-89) suggests that there are many advantages of C.A.L., but they can all be subsumed under the individualization of instruction. Majer (1973, p. 24) also contends that it is unlikely that a teacher could match the computer's effectiveness over a long period of time. Suppes (1965) suggests that only computer technology may be able to accomodate individual differences in subject matter learning. Lance (1977, pp. 92-97) maintains that with the implementation of Public Law 94-192 in the United States, an individualized program of instruction for every exceptional child can be achieved only with the help of computer technology.

Among its many advantages, vonFeldt (1977, pp. 7-8) reports that the use of C.A.L. in education results in:

1. the increased availability of the teacher's time;
2. individualized learning, at the student's own pace; and
3. reduced learning time.

These advantages were confirmed in a study conducted by Butman (1973). The results of his study revealed that significant reductions in training time occurred when students used C.A.L. In addition, the monitoring and reinforcing features of C.A.L. provided the students with the motivation and skills to move ahead at their own pace.

Cogen (1969, pp. 38-41) has listed seventeen advantages of C.A.L. in special education. Butman (1973) argues that C.A.L. is most economical and most effective when used in special education. Sandals (1973, pp. 36-41) states that in comparison to traditional methods of instruction, the handicapped child may benefit from C.A.L. since:

1. the material is presented in small logical steps so it is easy to master;
2. the student is able to work at his/her own speed;

3. the student is actively involved and receives immediate personalized feedback;
4. the use of small steps accomodates the student's short attention span and thereby focuses his/her attention on the learning;
5. the consistent immediate feedback helps the student to become an independent learner;
6. the teacher is better able to individualize his/her teaching; and
7. the student often becomes more highly motivated, and this may generalize in the form of improved behavior.

One of the main goals of special education is to provide the students with an individualized program of instruction. Both the general and specific advantages of C.A.L. strongly suggest that C.A.L. has tremendous potential to meet the specific needs of exceptional children. Research suggests that both P.I. and C.A.L. can provide the additional instruction and remediation that children in special education require.

Instructional Technology, P.I., and Language Skills

Woolman and Davy (1963) developed a series of programmed textbooks on reading skills for use with mentally retarded persons. It was found that the use of these P.I. texts significantly improved their achievement as compared to gains with conventional techniques.

Studies by Parsons (1963) and Naumann, Porter, and Wensley (1964) both obtained significant results in the acquisition of reading and writing skills using P.I. methods with mentally retarded children.

Malpass (1963) evaluated the effectiveness of automated instruction with Educable Mentally Retarded (E.M.R.) and Trainable Mentally Retarded (T.M.R.) institutionalized children. The results revealed that automated instruction was more effective than conventional classroom instruction in teaching word recognition, spelling and reading skills.

Blackman and Smith (1964) compared conventional classroom methods and programmed teaching machines in teaching reading to E.M.R. children. The results indicated that there were no significant differences between the methods of instruction.

Malpass (1966) tested the effectiveness of P.I. in teaching basic reading skills to slow learning, culturally different kindergarten children. Forty-five children were divided into three treatment groups: the control group received traditional classroom instruction; one experimental group was machine-taught; and the second experimental group used programmed workbooks. The results revealed that:

1. both experimental groups made significant vocabulary gains as compared to the control group; and
2. there was no significant difference between the machine-taught and programmed workbook methods.

Vergason (1966) compared automated slide projection instruction with traditional teaching methods with E.M.R. subjects. Results indicated that after periods of 1, 2, 4, and 15 months, significant differences in sight vocabulary retention rates were found in favor of the subjects who received automated instruction. Vergason concluded that the systematic overlearning produced by automated instruction might have been responsible for the different retention rates.

A study entitled The Peabody-Chicago-Detroit Reading Project, was instituted by Woodcock (1967) to compare six methods of teaching beginning reading to young E.M.R. children, who were non-readers. The six methods investigated were: (1) Language - Experience, (2) traditional orthography, (3) basal reader, (4) I.T.A., (5) Rebus, and (6) programmed textbooks. After two years of instruction, results indicated that there were no significant differences on seven reading achievement measures among the six methods. Woodcock concluded that instructional approach did not significantly affect the reading achievement of young E.M.R. children during the first two years of instruction if they were non-readers at the outset.

Warner (1967) used P.I. in teaching phonic skills with three groups of exceptional children: mentally retarded children; neurologically impaired children; and emotionally disturbed children. The results revealed that the mentally retarded and emotionally disturbed groups of children made significant gains between initial and terminal performance. Girls as compared to boys, and children younger than the mean age of eight, made more significant progress than those who were older than eight years.

Malpass, Williams and Gilmore (1967) compared two formats of P.I. and conventional instruction to teach reading and spelling to three groups of retarded children. It was found that both P.I. methods, the Mast Teaching Machine and programmed workbooks, were superior to conventional classroom instruction. There were no significant differences between the two P.I. methods.

Steg (1968) and Bender (1968) studied the effectiveness of two teaching machines in teaching reading and language skills to disadvantaged pre-kindergarten children. The machines used were the Edison Responsive Talking Typewriter and the Story Telling Automated Reading Tutor. Results revealed that both teaching machines were more efficient than regular classroom instruction.

A study undertaken at Tulane University (1968), measured the effects of group P.I. on reading to Head Start children. The Sullivan Associates Readiness in Language Arts was used with fifteen children in each of five experimental Head Start classes. Equal numbers of children were used in the control groups. The results revealed that the experimental group made greater gains in (1) recognition and identification of letters, and (2) familiarity with numbers and letters. The control group made larger gains in (1) familiarities and differences in word formations, and (2) understanding oral instructions and sensitivity toward sounds. Significant differences were obtained in some areas.

Ellson, Harris and Barber (1969) conducted a study in the Indianapolis city-center schools that evaluated the effects of programmed tutoring and traditional directed tutoring in teaching reading to first grade disadvantaged children. Two experimental groups received programmed tutoring either once or twice a day for fifteen minutes per session; while two control groups received either one or two daily sessions of directed tutoring. The results indicated that programmed tutoring was superior; however, only programmed tutoring twice a day was statistically significant.

Richardson and Collier (1971) used a highly-structured programmed method to teach basic reading skills to an experimental group of twelve dyslexic children. Post test results revealed that the experimental group was superior to a control on all measures of decoding, and that they could generalize these decoding skills to unfamiliar content.

Fricklas and Rusch (1974) evaluated the teaching effectiveness of the Trimodal Programmed Instruction in Reading with elementary school children. These children had been making limited or no progress in their reading programs despite other remedial procedures. Nine subjects interacted with a Teledesk which utilized the child's audio, visual and kinesthetic modalities. The Trimodal Reading Instruction approach employed the whole word method of reading instruction. After two months of instruction, post test scores revealed that the students' word recognition and comprehension skills increased dramatically.

P.I. and Arithmetic Skills

A study by Price (1961) compared three methods of teaching the principles of addition and subtraction to mentally retarded students. The three teaching methods used were: (1) programmed materials that required that the answer be written-in; (2) programmed materials that used multiple choice (MC); and (3) conventional teaching. The two experimental groups received instruction by means of teaching machines. Differences between the pretest and post test scores indicated that there were no significant differences between the three groups in the amount learned except in subtraction where the MC machine taught group was superior. The results also revealed that the two machine taught groups made as much progress, but required considerably less time than the conventional teaching group.

Blackman and Capobianco (1965) evaluated P.I. using teaching machines to teach reading and arithmetic to E.M.R. adolescents. An experimental group was taught by teaching machines, while the control group was taught by traditional methods. The findings indicated that both groups improved significantly in both subject areas, but no superiority was shown by either teaching method.

Rainey (1965) also evaluated commercial P.I. in arithmetic with two matched groups of E.M.R. subjects. The experimental group used a MIN-MAX Teaching Machine to drill multiplication and division facts. The control group received regular classroom instruction. The results revealed that there were no significant differences between the two methods; however, there were consistent differences in favor of the experimental group.

In a follow-up study, Rainey and Kelly (1967) compared the effectiveness of a commercial programmed arithmetic textbook with two teacher made programs with three matched groups of E.M.R. students. The three methods that were evaluated were: (1) the TMI Grollier Multiplication and Division Facts Program; (2) an understanding approach; and (3) a presentation-practice (rote) approach for learning arithmetic facts. The results indicated that the rote approach was significantly better for learning division facts, while no treatment differences were found for multiplication. The authors suggested that the subjects would benefit from P.I. if they were above the 2.3 grade level in reading achievement.

A comprehensive study by Coss (1966) researched the effectiveness of P.I. in teaching fractions and decimals to a group of secondary students who were physically handicapped. The subjects were divided into four matched treatment groups. One group remained continuously with the teacher, and another group continuously with the teaching machines (T.M.). Two groups alternated between the T.M. and the classroom.

Results among the treatment groups revealed that:

1. T.M. instruction was approximately two-thirds more efficient in time;
2. T.M. instruction was most effective in conjunction with classroom instruction:

3. T.M. instruction was most effective for students with lower levels of intelligence;
4. classroom instruction became more effective as the instructional material became more complex;
5. T.M. instruction followed by classroom instruction was the most effective sequence; and
6. the teaching machines could be adapted for use by physically handicapped students.

Coss concluded that automated visual instruction for the physically handicapped was effective in that:

1. P.I. was more efficient than conventional instruction for this population;
2. automated instruction was under the control of the student which enabled the educational progress to be maintained, notably in situations where instructional time was reduced due to medical priorities;
3. P.I. permitted individual students to work independently at their appropriate grade levels; and
4. teaching machines have the capability of providing a variety of subject content to suit curriculum or individual needs.

Johnson (1966) studied the effectivness of different techniques to teach arithmetic to mentally retarded subjects. It was found that the group which used a programmed sequence in combination with conventional classroom lessons showed significantly better results than groups which used: (1) a program designed by Johnson; (2) T.M.I. Grollier's Elementary Arithmetic: Addition and Subtraction Facts; or (3) conventional classroom lessons.

Metzger (1966) used a teaching machine and a P.I. text to teach basic addition facts to E.M.R. pupils. The results indicated that both the teaching machine and the P.I. text could be used successfully with these students.

Haskell (1967) compared P.I. and conventional instruction in teaching four basic arithmetic rules to two matched groups of children who had cerebral palsy. After thirteen weeks of instruction, there were no differences between the two treatment groups. Haskell concluded that P.I. was as good as conventional methods, and that the more severely handicapped children benefitted the most from P.I.

Higgins and Rusch (1967) effectively used a teaching machine, the audio-visual manipulative (AVM) desk, to teach arithmetic concepts to E.M.R. children. The results from four separate field studies revealed that the AVM method was effective, and that higher post test scores were obtained when the children went through the program twice instead of just once.

Kaplan (1969) used non-verbal P.I. to teach mathematics to disadvantaged inner-city children. The programs were designed to teach simple additive and subtractive operations. Post test results, based on six children who completed the program, indicated that the mean scores rose by 6.3 points. The degree of improvement ranged from an increase of 28% to 57%. Kaplan concluded that:

1. P.I. can be used as supplementary materials, and can be used by the least advanced students;
2. teachers can learn considerable knowledge about students' learning behavior as they work through the planned sequences which aim toward specific behavioral objectives in P.I.; and
3. P.I. enables teachers to "zero-in" on particular behavioral objectives.

Dezelle (1971) compared P.I. and conventional classroom techniques in teaching arithmetic to junior high school students who were mentally retarded. No significant differences were obtained between the experimental group and the conventional group between pretest and post test scores on the California Achievement Test. Similar results were obtained by Thilbodean (1974) who used P.I. to teach math to E.M.R. students.

In a two year study in Tacoma, Washington (1971), investigators used the techniques of precision teaching to improve the academic performance of disadvantaged children who had been labelled mentally retarded. Included in this program were: the systematic arrangement of instructional cues; programmed learning; reinforcement contingencies; and continuous measurement of performance. The results showed that mean grade gains in reading and math were approximately three times higher for the experimental classes than for the control groups. The results suggested that a high percentage of children from an economically depressed area are labelled mentally retarded for socio-environmental reasons. Furthermore, the results indicated that such children are capable of acquiring basic skills in a learning environment which maximizes pupil performance.

Collins and Calevro (1974) used P.I. and a peer tutoring system to improve the math skills of nine grade eight students in a mainstreaming program. The students, whose math skill deficits ranged from 3.8 to 6.6 years, met daily with peer tutors for one half hour of instruction from the Sullivan Associates Programmed Math Series. After three months of instruction, the students' achievement improved dramatically.

P.I. With Deaf Students

P.I. is a form of independent study that offers valuable learning opportunities for deaf students. Stepp (1971, p. 444) suggests that the strength of P.I. is found in the logic of its principles. Stolurow (1960, pp. 78-83) and Pfau (1970, p. 14) both contend that P.I. has application and advantages in special education. Snyder (1971, p. 448) indicates that there are certain unique advantages of P.I. from the students' perspective.

Falconer (1962, pp. 390-91) claims that there are distinct advantages of P.I. for use with deaf students. Stuckless and Birch (1964, p. 296) state that since P.I. is a visual medium, it can be used as a formal method of language instruction with deaf students.

One of the first investigations of the use of P.I. with deaf students was conducted by Thompson in the 1920's (Thompson, 1964, pp. 349-53). Ten young deaf children were given special reading instruction for eight months. The children worked independently at their own rate with "quasi P.I." materials--vocabulary flash cards, direction sheets, book material, and practice sheets. A matched group of controls continued with their regular instruction. Results indicated that the experimental group made significant gains in reading scores over the control group. These results suggested that language and reading skills of deaf children could be accelerated by the proper use of scientifically organized instructional materials.

Since 1959, there have been more than forty investigations in which P.I. has been used with deaf children (Pfau, 1969, p. 24). In addition, approximately sixty different teaching machines have been used to teach different skills to deaf children (Pfau, 1970, p. 15). In general, the results indicate that P.I. has had a high motivational value for deaf students. This research of the use of P.I. reflects the search for more effective materials and better methods of presentation that will best meet the needs of deaf students.

One of the first major investigations of the use of P.I. with deaf students was conducted by Falconer (1961, pp. 251-57). He used a teaching machine to teach sight vocabulary to eight young deaf children. The results of both the post test and retention test suggested that P.I. was an effective adjunct to classroom instruction. Falconer's research led to numerous later investigations.

Fehr (1962, pp. 14-21) used P.I. to teach the indefinite articles "a" and "an" to a small group of eight-to-ten year old deaf boys. Results indicated that the students were able to transfer the newly learned principles to classroom language activities.

In their respective studies, neither Falconer nor Fehr used a control group. Consequently, their conclusions were confined to statements that learning had taken place (Stuckless and Birch, 1962, p. 415). However, each study demonstrated that P.I. could be used successfully with deaf students.

Beckmeyer (1963, pp. 415-17) used comercially prepared programmed materials to teach reading to ten deaf children. The results indicated that it was feasible to use programmed material that had been designed for hearing children, with deaf children, if the deaf children have the prerequisite reading grade skills required by the program.

Birch and Stuckless (1963, pp. 317-36) compared P.I. and regular classroom instruction on the development of written language of ninety-nine deaf students. Their results indicated that expressive grammar could be taught by P.I. in less than half the time that conventional instruction required. They also found that the grammar of adolescent deaf students could be improved significantly by using P.I. that was constructed to remediate specific areas of language difficulty. The authors concluded that programming written language for deaf students was very feasible.

In a second study, Birch and Stuckless (1963) compared P.I. with conventional instruction to correct grammatical errors in deaf adolescents. The students were assigned to one of three groups: experimental group One which received a single presentation of the language program; experimental group Two which had repeated presentations of the language programs; or the control group which received traditional instruction. The results revealed that repeated presentations of the same programs, when coupled with conventional instruction, resulted in the greatest improvement. Stuckless (1964; as reported in Rosenstein, 1966, p. 191) subsequently divided the P.I. groups and found that P.I. had failed to reduce the number of errors in language in children who had had a good knowledge of grammar at the beginning of the study.

Roy, Schein, and Frisina (1964) used an electric typewriter and P.I. to teach reading to deaf children three to seven years of age. The results indicated that P.I. produced significant language improvement as compared to the gains made by a matched control group using traditional methods. The authors suggested that coordinated programmed language exercises on the typewriter could supplement the regular language program.

Rush (1964, pp. 356-58) developed a linear program to teach fifty seven deaf children the language of directions as used in tests and workbooks. Results revealed highly significant gains in comprehension. P.I. was found to be an effective and time saving procedure. A revised version of this study has since been commercially disseminated (Rush, 1972).

In another experiment, Rush (1966, pp. 219-26) investigated the use of programmed materials in teaching written language to thirty eight children ages eleven to seventeen years. Results indicated that a significant amount of improved learning occurred, which suggested that P.I. may have wide application to teach language skills to deaf and other language-handicapped people.

A comprehensive study was undertaken by Karlsen (1966) to teach beginning reading to five year old, hearing impaired children, using an automated instructional system of visual reading instruction. The teaching machine used was the Honeywell University of Minnesota Instructional Device (HUMID). After two years of study, Karlsen concluded that the teaching machine (1) could be used to teach young deaf children to read, (2) was uniquely well equipped to present the printed word effectively, and (3) had a place in every classroom for deaf children, either as the basic system of teaching reading or as a system of supplemental reading instruction. The most significant conclusion drawn, however, was that it would require an inordinate amount of programming to develop a system of reading materials that would bring deaf children up from beginning reading to a fourth grade reading level.

Scherer (1967, pp. 1997-2011) used P.I. and an automated teaching device to study the reading processes of deaf children through the simultaneous presentation of stimuli. Three matched groups of young deaf children, ages six to ten years, were assigned to one of three experimental groups: (1) speechreading, pictures, and the printed word; (2) printed word and pictures and (3) speechreading and the printed word. The results indicated that the students who received the simultaneous presentation of the three stimuli obtained statistically significant higher scores on the paragraph comprehension and sentence comprehension tests. It was concluded that the presence of the three stimuli, when presented in a programmed learning format, led to more effective learning of reading skills.

Lennan (1969, pp. 906-11) used teacher prepared programmed materials to teach basic vocabulary and language patterns to sixteen emotionally disturbed boys. Teachers' evaluations of the students' performance revealed that P.I. also improved teachers' effectiveness in the planning and teaching of their programs.

Brown and Arkebauer (1970, pp. 81-85) found that the Language Master was an effective tool to teach vocabulary to young hearing impaired children. In addition it was also noted that it enabled the children to assume a greater role of responsibility in their educational development; and the Language Master provided added flexibility in classroom management.

Grigonis (1970) used P.I. to teach verb vocabulary and sentence structure to seventy eight deaf children five to ten years af age. Significant gains were obtained in verb vocabulary and sentence structure. The author concluded that P.I. constituted an effective and efficient teaching technique; and that it had wide spread applicability for young deaf children.

One of the largest and most comprehensive P.I. endeavour for the handicapped to be carried out on a longitudinal basis is Project LIFE--Language Instruction to Facilitate Education of hearing impaired children. It consists of programmed linear filmstrip lessons on perceptual training, cognitive thinking and language/reading. Also, there are supplementary materials--story books, workbooks, and picture dictionaries. The program is intended to teach receptive language skills and significantly increase the language learning rate of hearing impaired children. By using the program it is hoped that the child will discover "that he can learn independently and that learning can be fun" (Pfau, 1972, p. 18). Although the program has been field tested and validated in many centers since 1963, and has been commercially available since 1973, this writer knows of very little empirical research that has studied the efficacy of the program.

McKinney (as reported in Spidal and Pfau, 1972, pp. 33-41) used Project LIFE to teach language and communication skills to nine illiterate deaf adults. Following a subjective evaluation of their post-program language and communicative behavior, she concluded that all subjects made substantial gains in their linguistic competencies and communication skills.

Vockell et al. (1973, pp. 431-39) studied the effectiveness of the Perceptual Training and Thinking Activities Programs of Project LIFE with two groups of mildly retarded deaf children, ages eight to twelve. Results revealed that both groups showed improvement in perceptual and thinking efficiency. The lack of a control group and/or randomization of the sample prevent generalization of the findings; however, the results suggest further research be undertaken.

The research discussed to this point suggests that P.I., as compared to regular teaching methods, has been quite successful in teaching language skills to deaf students. However, there is some research that suggests that P.I. is ineffective. Devine (1971; as reported in Cline, 1974, p. 93) compared P.I. with regular classroom instruction and found that although the scores for children using P.I. were higher, they were not significantly higher. Pfau (1969) found that P.I. was not effective in teaching expressive language to deaf students. Stepp (1971, p. 444) reported that the initial use of P.I. with deaf students was not too successful because the reading vocabulary in the commercial programmed material was too difficult.

Cline (1974, p. 93) suggests that P.I. may be more effective in teaching certain language skills, such as simple reading skills and simple sentence construction, and that it may be less effective than traditional instruction in teaching speech skills and vocabulary. The limits of P.I. may suggest that appropriate programs to teach these speech and vocabulary skills have not yet been developed. For P.I. to be effective with deaf students, the vocabulary, grammar and syntax must be carefully chosen and written, and illustrated with a great variety of colorful pictures (Karlsen, 1965, p. 539).

The lack of linguistic competence in standard English is the outstanding handicap of deaf persons. Consequently, the area of language has received more attention, discussion, and research than any other aspect of deafness. Suppes (1974, pp. 165-66) reports that there are few detailed studies, apart from data on achievement tests, that deal with the mathematical abilities of deaf students beyond the skills of arithmetic. A recent survey by Johnson (1977, pp. 19-25) of mathematics programs, materials, and methods in schools for the deaf indicated that among the 58 schools surveyed (1) approximately 20% are using programmed mathematics, (2) 16% are using C.A.I. in mathematics, and (3) less than 5% of instructional time is utilized for individualized instruction in mathematics.

A study by Bornstein (1964) found that P.I. was no more effective than the lecture method in teaching high school maths to deaf students. Furthermore, P.I. required as much and often more time than the lecture method. Bornstein noted, however, that P.I. has a potential advantage for those students who complete the programmed materials prior to an alloted standard of time. The problem Bornstein feels, is to identify these students before they begin to use programmed materials.

The following studies of P.I. demonstrates the potential for diverse use of P.I. in deaf education. Fessant (1963, pp. 241-44) has used P.I. successfully to teach vocabulary, measures and principles in industrial arts. McGrady (1964, pp. 531-36) used P.I. to study conceptual learning of two matched groups of young deaf and hearing children. The significant gains made by the deaf children between pre and post tests indicated that P.I. could be used in a program to help develop their conceptual thinking.

P.I. has been used successfully to teach lipreading skills to hard-of-hearing and deaf students (McDearmon, 1967). Neyhus (1967) found that P.I. in the format of motion picture films, was more efficient than traditional methods in teaching lipreading skills.

Doehring (1968) used P.I. in picture-sound association to assess the nonverbal, auditory perceptual abilities of deaf children. The results suggested that systematic P.I. might be a very efficient means of teaching specific auditory-visual associations; and that such a system could help profoundly deaf children to learn to identify meaningful nonverbal sounds.

Stepp (1971) used a self-instructional P.I. system to develop speechreading skills in ten young hearing impaired children. The programmed system consisted of an 8 mm film projector, cartridge films, and a set of headphones. Results of the program indicated that the children could assume responsibility for some of their learning, and that speechreading could be programmed for individual learning.

Effectiveness of P.I.

Many research studies that have compared P.I. to traditional classroom instruction have concluded that P.I. was more effective. Schramm (1964) and Hartley (1966), however, have reviewed a large number of experimental studies in a variety of subject areas and grades, and found that P.I. was only slightly superior to conventional instruction. Similar results were obtained by Lange (1972).

Fry (1968) has also compared the effectiveness of P.I. with traditional classroom teaching. Fry concluded that the research literature had not established the superiority of P.I., especially in the field of reading. Fry suggested that the value of P.I. was that it enabled the teacher to individualize instruction and thereby meet the needs of more students. A review of past research led Bachor (1973) to conclude that there was little empirical evidence to support the use of P.I. in elementary language instruction.

Zoll (1969) reviewed thirty five research studies that used P.I. in mathematics and found that there were no significant differences between P.I. and traditional instruction. The research did suggest, however, that students may require less time to complete programmed materials.

Krumboltz (1963; as reported in Lumsden, 1974, p. 148) asserted that comparisons between P.I. and conventional classroom instruction were questionable in that:

1. classroom teachers vary so widely in conventional instruction that there is no stable basis for comparison;
2. programmed materials vary widely in their scope and quality of writing; and
3. the criterion test may have been designed to measure only a limited objective.

Jamison _et al_. (1974, p. 41) noted that the current research emphasis in P.I. has changed from comparative studies of effectiveness to studies of how to improve the programs and how to increase student interest. Jamison also suggested that future studies research how student variables relate to achievement in P.I.

C.A.L. With Special Education Students

The advantages of C.A.L. for students in special education have been extolled since the early 1960's. The most intensively researched area has been that of the effectiveness of drill and practice programs in elementary mathematics and reading. The research findings have shown positive results for exceptional children using C.A.L.

C.A.L. Mathematics Programs

Prince (1969) conducted a two year study using C.A.L. with disadvantaged children. C.A.L. drill and practice programs in mathematics were used in seventeen schools. At the end of the first year of the study, a significant difference was found in favor of the groups using C.A.L. as compared to the groups who had regular instruction. A more detailed analysis in the second year indicated that there was no significant difference between C.A.L. and regular instruction. However, significant differences were found in favor of Negro and low income groups using C.A.L. as compared to other teaching methods.

Stovall (1969; as reported in Gipson, 1971) and Gipson (1971) each studied the effectiveness of C.A.L. in teaching mathematics to culturally disadvantaged children. Stovall reported that a drill and practice C.A.L. program was used effectively to teach mathematics to 700 elementary school children. The results revealed that the experimental groups scored significantly higher in computational skills than did the control groups. Gipson used C.A.L. to supplement the maths program for grade seven students. Significant gains were shown on a test directly related to the programmed materials. However, significant gains were not demonstrated when a standardized achievement test was used.

Beech *et al.* (1970) evaluated a Dial-A-Drill program for disadvantaged students in New York City Schools. The students, in grades two to six, were telephoned at home and given three practice sessions a week in oral arithmetic problems. Each practice session was five minutes in duration. The exercises were generated from digitized word recordings stored on a computer disk, and the students responded on a touchtone dial telephone. Results indicated that there was no significant difference between the experimental and control groups at all grade levels. It was suggested that the lack of sufficient computer contact time was responsible for the lack of measurable differences between the groups.

The authors also surveyed the attitudes of both the students and parents to the Dial-A-Drill program. Both groups responded favorably to the experiment, which surprised the authors since they felt that this population, which was drawn from the poverty areas of New York, generally had a negative attitude towards education.

Crawford (1970) used C.A.L. as a remedial technique to teach arithmetic to underachieving students. The experimental group received C.A.L. in addition to regular classroom instruction, while the control group received only classroom instruction. Although the experimental group made significant gains, statistical significance was not obtained between the two groups. It was felt that frequent equipment failures, insufficient staff training, a high rate of absenteeism, and an insufficient experimental period of only eight weeks may have contributed to the lack of significance between the experimental and control groups.

Knutson and Prochnow (1970) successfully used a C.A.L. simulation program to teach money management skills to Trainable

Mentally Handicapped (T.M.H.) students. The computer apparatus consisted of a teletype terminal interfaced with slide presentations and audio instructions. The terminal keyboard was designed with ten oversized keys, which permitted actual coins to be placed on the keys. There were significant differences between pretest and post test scores. The authors concluded that C.A.L. was an effective method in teaching social skills to T.M.H. students.

Gipson (1971, p. 11) indicates that there are four advantages of using C.A.L. programs. The C.A.L. system can (1) provide highly individualized mathematical instruction to a large number of pupils daily, (2) perform an immediate analysis of the pupil's mathematical responses, making possible individualized instruction, (3) keep each pupil and his/her teacher informed of the pupil's progress, and (4) provide reports to the teachers on class performance and item reliability for use in daily planning.

Street (1972) investigated the use of C.A.L. to improve the basic arithmetic skills of disadvantaged elementary school students. Standardized test scores revealed that there was no significant difference between experimental C.A.L. groups and control groups. The lack of significant gain was attributed to (1) frequent computer shutdowns, (2) students working on inappropriate programs, and (3) lack of supervision of students and the programs they used.

Sandals (1973) studied the effectiveness of C.A.L. in teaching banking concepts to T.M.H. young adults. Concepts such as budgets, deposits, and withdrawls were taught on teletype terminals that were interfaced with a slide presentation. Significant differences were shown between pretest and post test, and between pretest and retention test scores. The results also revealed that the subjects were able to transfer these skills to new situations. It was concluded that C.A.L. was an effective means of teaching money management skills to T.M.H. persons.

Hill (1976) studied the effectiveness of C.A.L. drill and practice programs in arithmetic with physically handicapped children. The experimental group received C.A.L. in addition to regular classroom instruction, and the control group had only classroom instruction. The results indicated that there was no significant difference between the two groups. However, the C.A.L. group made significant educational gains in that they showed an increase in grade level of seven months as compared to a three month gain for the control group, during the four month experimental period.

C.A.L. and Language Arts Instruction

Several researchers strongly advocate the use of C.A.L. in language instruction, especially at the elementary school level. Schiavone, Rowen and Farrell (1971) suggest that C.A.L. as a supplement to reading instruction has several distinct advantages over traditional methods. Studies by Fletcher and Atkinson (1972), Fletcher and Suppes (1972), and Atkinson _et al._ (1973) have shown that students, when using C.A.L., have made significant and consistent gains over what would be expected from classroom instruction alone.

Martin (1964) compared the effectiveness of the Edison Responsive Environment Instrument (E.R.E.) with a conventional method in teaching reading to two matched groups of kindergarten children. The E.R.E. is a multimedia computerized typewriter designed specifically for reading instruction. The experimental group consisted of twenty two children, some of whom were mentally retarded. The experimental group used the E.R.E. for thirty minutes each session over a five month period. The control group was taught by enriched conventional reading methods. The results indicated that the experimental group learned to read significantly better than the control group. The scores of the retarded children improved as much as those of the other children. It was felt that the differences between the experimental and control groups would have been greater if the experiment had continued.

Green (1968) used a multimedia system--slides, a teletype terminal, and tape recorder--to teach disadvantaged, four year old children to recognize words and letters. C.A.L. was tested with middle class and disadvantaged children. It was found that the programs were more suitable for the middle class children. Green felt, however, that a C.A.L. approach was also well suited for disadvantaged children.

Majer (1972, pp. 78-81; and 1973, pp. 23-26) reviewed a variety of C.A.L. reading programs--remedial, regular curriculum, and special education--that had been successful on a range of variables. These studies revealed that with C.A.L., students: (1) can learn to read;

(2) are motivated; (3) have improved attitudes to learning; (4) have better school attendance; and (5) have improved their behavior. In addition, with C.A.L. teachers were able to make better diagnosis of reading problems earlier in the school year. Majer (1972, p. 94) concluded that there was a need to go beyond our "traditional instructional strategies in reading", and that computer technology has "the potential for the level of individualization necessary for personalized reading instruction" (Majer, 1973, p. 23).

Nelon (1972) researched the effectiveness of C.A.L. with twenty four elementary school children. Twelve of the subjects were E.M.R. and twelve were children with normal intelligence. The subjects were judged to be relatively equivalent in mental age and developmental levels. The experimental group, which consisted of E.M.R. and normal children, received computer assisted vocabulary instruction. A matched control group received only the post test. The results indicated that there were significant differences on the post test scores in favor of the experimental group. Further analysis revealed that, for subjects of comparable mental age, there were no significant differences between the E.M.R. and normal students in learning, error rate, and the time required to complete the program.

Elfner (1973) conducted a three year reading program for forty E.M.R. children. The project used C.A.L. in a programmed format in the first year. In the second year, C.A.L. was converted to computer managed instruction. During the final year, supplementary instruction was presented without the use of the computer. The results revealed that: (1) significant gains were made by the forty students; (2) the students required more drill and practice than originally thought; and (3) students who took more time to respond to questions on the computer showed more gains on the post test.

Smetana *et al*. (1975) used a highly structured computer assisted language arts system, the Oralographic Reading Program, to teach reading skills to learning disabled students. The students, ages seven to twelve years, were neurologically or perceptually impaired. At the beginning of the project, the students were non-readers. The program was designed to develop skills in phonetic decoding, reading, writing and problem solving. The students worked approximately one hour per day with three learning instruments--the Talking Page, the Talking Typewriter, and the Voice Mirror. After eight months, the students were able to decode words, and were able to read at the second grade level.

C.A.L. In Both Mathematics and Language Arts

A two year C.A.I. project was implemented to teach arithmetic and reading to disadvantaged youths and adults (Hankin *et al*., 1967). This project was to serve as a prerequisite for entering vocational training. The project was concluded after only one year because funding was terminated. However, the results after the first year indicated that it was feasible to use C.A.I. to teach arithmetic and reading to disadvantaged youths and illiterate adults.

Leonard (1970) developed a C.A.L. project for eleven students who had learning problems. C.A.L. programs were developed specifically for these students in elementary reading, maths, and spelling. In addition, commercially prepared programs in arithmetic were used. The terminal was interfaced with slides and an audio component. After five months of instruction, the results of a standardized achievement test revealed that the students obtained improved scores on the reading, arithmetic and spelling subtests. It was concluded that C.A.L. was a beneficial teaching device.

Litman (1973) successfully implemented a C.A.L. program for underachieving, elementary students. The drill and practice programs, in reading, language arts, and mathematics, had been developed commercially. After one year, the results showed that the students obtained achievement scores at the "normal" rate of one month grade level gain for every month of C.A.L. instruction. These were better gains than traditional gains of 5.6 months for every 8 months of instruction in other special educational programs. In addition, greater gains were made in language arts and maths than in reading. Students who completed more than 100 C.A.L. sessions scored very high gains. It was concluded that the project was highly successful in providing individualized instruction.

Berthold (1974) researched the effectiveness of three different methods of teaching mathematics and spelling to eleven minimally brain damaged children. The three methods compared were (1) C.A.L., (2) the teacher, and (3) C.A.L. in combination with the teacher. Significant gains in achievement were obtained by the teacher, and the C.A.L.-teacher combination. It was suggested that the poor performance of the C.A.L. method could be attributed to (1) inadequate numbers and levels of C.A.L. programs; and (2) the computer program was not being fully utilized to meet the needs of the students.

St. Aubin (1976) developed a C.A.L. project for 198 handicapped children in Chicago. Students who had hearing, visual, mental, orthopedic, or other learning disabilities were enrolled in C.A.L. math, reading, or language arts programs that had been developed commercially. The results of a five month evaluation period indicated that the students' academic progress was directly correlated to the amount of computer contact time they had had. A survey of the teachers revealed that they were positive about the benefits of C.A.L. for their students.

Fiorentino (1977) investigated the use of C.A.L. with junior high school students who had learning disabilities. Drill and practice C.A.L. programs were used to teach basic computation and spelling skills. Three random groups of subjects were randomly assigned to C.A.L. arithemetic, C.A.L. spelling, and to a control group. After a three month experimental period, the results of a standardized achievement test showed that there were no significant differences among the three groups. Further analysis of the results revealed that there were significant differences over time for both arithmetic and spelling which were attributed to C.A.L. The significant differences over time in arithmetic were due to the gains made by the C.A.L. arithmetic group. Similarly, spelling gains obtained over time were due to the gains made by the C.A.L. spelling group. These latter gains, however, were not statistically significant. It was concluded that C.A.L. was an effective aid in drill and practice routines in both arithmetic and spelling for students who had learning problems.

C.A.L. in Use in Deaf Education.

C.A.L. has been used by deaf students since 1968-69. In 1970, the Institute for Mathematical Studies in the Social Sciences (IMSSS) at Stanford University instituted a three year C.A.L. project for hearing impaired and deaf students. The computer network involved over 4,000 students in 15 schools for the deaf in 4 states and the District of Columbia. C.A.L. curricula were developed in: (1) elementary maths; (2) arithmetic word problem solving; (3) language arts; (4) basic English; (5) algebra; (6) computer programming in AID; (7) computer programming in BASIC; and (8) logic and algebra. Specifically, the language arts and elementary mathematics curricula were evaluated during the three year project. In their final report on the project, Fletcher and Suppes (1973) concluded that C.A.L. : (1) can significantly benefit deaf students; (2) is economically practical; and (3) can support serious research with deaf students.

Following is a summary of the results of the two main studies in the elementary maths and language arts curricula with elementary and secondary school students (Suppes and Fletcher, 1974, pp. 129-31):

I. Mathematics strands experiment--Suppes, Fletcher, Zanotti, Lorton, and Searle (1973) studied the effect of varying numbers of mathematic strand sessions on the acquisition of computational skills. The results indicated that: (1) C.A.L. maths strands curriculum enabled deaf students to achieve Grade Placement (G.P.) gains in mathematical computation expected of normal hearing students; (2) these gains were two to three times greater than classroom instruction; (3) the more often the students used the computer, the greater the G.P. gain; and that (4) G.P. gains could be achieved in short and intensive daily sessions in a supplementary drill and practice program, in cooperation with regular classroom instruction.

II. Language arts experiment--This experiment conducted by Fletcher and Beard (1973) was analagous to the maths strands experiment. That is, each student was allowed to take only a specified number of language arts sessions. The results indicated that varying the number of sessions did not have a significant effect. Fletcher and Suppes (1973) concluded that the program was of significant value for those students who completed many of the sessions that they attempted, but of much less value for those students who completed few of the sessions they attempted. The results of this experiment raise the question whether or not similar results would have been obtained with only regular classroom instruction.

Suppes and Fletcher (1974, p. 131) concluded by asserting the value of the three year project. They note that 13 of the 15 schools that participated in the project have continued to use C.A.L., financed by their own funding; while two new schools will be added to form one network "that directly resulted from this project".

Further analysis of the Stanford project by Fletcher and Suppes (1976) has yielded additional, interesting findings. First, if deaf students received one ten minute C.A.L. mathematics session per day for at least two-thirds of a school year, a G.P. improvement of 1.0 to 1.5 years can be expected. This is an improvement over the usual G.P. increase of 0.3 to 0.4 years obtained with classroom instruction. Second, Suppes, Fletcher and Zanotti (1976) have demonstrated that precise G.P. gains can be predicted as a function of C.A.L. sessions. Thus, it is possible to individualize instruction both in the amount of instruction required and in the G.P. goal established for each student. Third, the performance data indicated that the cognitive performance of deaf students was as good as that of normal hearing students on tasks that did not directly involve verbal skills. Finally, Fletcher and Suppes noted that the average cost of C.A.L. for each school was $300 per month or $.60 per student session. These figures were based on twenty-five student sessions per day for twenty days each month per terminal. The authors further suggested that many of the schools had more than twenty-five student sessions per day, which substantially reduced their costs per session.

In summarizing the effects of C.A.L. drill and practice maths programs used at the Kendall School for the Deaf, Behrens, Clack, and Alprin (1969) noted that the students' motivation had been consistently high; and that the students demonstrated increased maturity towards learning, especially towards tests and errors. Perhaps most significant, however, was the finding that the students were able to handle, in word problems, the language they were unable to handle in the classroom.

Barnes and Finkelstein (1971, p. 468) have aptly stated that C.A.L. provides educators of the deaf, with an opportunity heretofore unobtainable--that of tailoring instruction to the needs of the individual learner, so as to provide an efficient and effective learning process. It is in this manner that a computer based system is being used to assist deaf students at the National Technical Institute for the Deaf in Rochester, New York to prepare for advanced maths.

Since 1973, San Antonio College in Texas has used C.A.L. to teach English to freshman students (Rudisill and Jabs, 1976).

The program was also adapted for use with hearing impaired students at the college. C.A.L. was interfaced with illustrated slides and video tape. The lessons on the video tape were presented in total communication which enabled the hearing impaired students to work successfully on the terminals. Results of a study revealed that the composition grade scores of the freshman students had improved dramatically. The authors concluded that C.A.L. was playing a significant role in the learning process of hearing impaired students.

Weyer (1973) conducted a C.A.L. project which used computer graphics to teach fingerspelling and to measure the configuration similarities in fingerspelling. The project was evaluated in two separate experiments. The first experiment measured the subjects' ability to read fingerspelled sentences at different rates of speed. The second experiment measured similarities between fingerspelled letters by assessing the confusion caused by the rapid presentation of fingerspelling. Overall results of the two experiments indicated that the computer-generated alphabet was a useful tool for teaching fingerspelling, and for obtaining measures of fingerspelling similarities.

A C.A.L. project was undertaken in mathematics and reading for 400 visually or hearing impaired students in the Cincinnati public schools (Morgan, 1975). Students were given pretests to determine their needs, and the teachers were trained to develop appropriate C.A.L. programs and to monitor the students progress.

At the end of the first year of the project, the results demonstrated that C.A.L. was beneficial with deaf students; and that the deaf students obtained better scores in mathematics than in reading. Responses to a questionnaire revealed that the deaf students, their parents, and their teachers reacted favorably toward the use of C.A.L. The results of the first year also indicated that further hardware and software development was necessary before C.A.L. could be fully implemented and tested with visually impaired students.

In September, 1975, C.A.L. was instituted at the Scranton State School for the Deaf in Scranton, Pennsylvania (Fricke, 1976). A minicomputer and twenty teletype terminals were installed, and commercially prepared drill and practice programs in elementary mathematics, reading, and language arts were used with the students. In the first year of the project, middle school students averaged a 1.3 grade level gain in mathematics and a 0.4 gain in reading. High school students showed a 1.1 grade level gain in mathematics and a 1.3 gain in reading. Teachers reacted favorably toward C.A.L., but complained about the level and limitations of the curricula. The total cost of the system projected for five years was estimated at \$180,000. Based on the first year's average of 1.7 hours of use per student per week, the average cost per student hour was \$3.80.

Madachy and Miller (1976) reported that C.A.L. had been used to help college students, who were deaf, to master basic English structures. The C.A.L. programs were based on an English as a second language format, since it was felt that the deaf students' first language was sign language. The lessons began with a pretest and then branched to appropriate drills. Some of the vocabulary lessons were coordinated with video tape presentations in American Sign Language and Signed English. Future plans included further development of video tape computer linkups, whereby language concepts are presented in sign language, and then drill and practice is provided by means of C.A.L. In addition, it was anticipated that C.A.L. lessons would be introduced into the regular curriculum with emphasis on language skills, reading, and remediation.

Newcomb (1976) predicts that computer aided language instruction in deaf education will go beyond current C.A.L. drill and practice routines to that of providing automatic grammatical analysis. He foresees that grammatical processing programs will be developed which will permit computers to understand English sentences. With a model of English grammar, the computer then could judge the grammatical correctness of any sentence produced by the deaf student. The computer could identify the type and location of any errors, and could provide immediate corrective feedback. Newcomb suggested that if the students were able to respond with unrestricted sentence production on the computer, and if the computer provided large quantities of remedial language practice, then the use of grammatical processing programs could result in a significant improvement in English language achievement for deaf students.

Nomeland and Harris (1976) developed a C.A.L. laboratory with drill and practice exercises in mathematics for deaf students at Kendall School in Washington, D.C. The curriculum offered two basic math options, fixed and mixed strand. During the first year 111 students, ages eight to fifteen years, participated in the project. At the end of the first year, results of the Stanford Achievement Test revealed that (1) 20 out of 28 lower elementary students achieved at least a one grade level increase in math, and 8 students increased two years; (2) 15 out of 33 upper elementary students demonstrated a one grade increase; and (3) 8 out of 23 middle school students increased one grade level or more. The lower achievement gains for the middle school students were attributed to the fact that most of them remained in the mixed strand programs for most of the year, and that their achievement test scores may have been invalid.

C.A.L. has been used successfully in a variety of disciplines--English, mathematics, chemistry, and foreign languages--with hearing impaired students at Gallaudet College in Washington, D.C. (Torr, 1976). Both drill and practice, and simulation modes have been used to teach these subjects. Torr concluded that the experimental use and cost of C.A.L. was justified given the magnitude of the educational difficulties faced by hearing impaired students.

Kearsley et al. (1977) developed a C.A.L. program that taught deaf children how to use a ruler. The program required the students to draw a dimensioned form according to specifications, involving the blending of a set of cognitive skills with psychomotor skills. The program was highly visual, and almost all responses required in the program were done by pointing on the cathode ray tube with a lightpen. Of the fifteen students who started the program, twelve completed it in three sessions. The lessons were presented one week apart. Analysis of the performance data revealed that C.A.L. provided efficient instruction. Two spin-off benefits of the program were also observed: (1) the students learned the necessity of reading and following instructions; and (2) they learned the need to be precise in their pointing responses. The authors concluded that more exposure to C.A.L. might not only improve the specific target skills, but it might also contribute to a greater general learning ability.

Smith and vonFeldt (1977) used two separate studies to compare the effectiveness of C.A.L. and Instructional Television in teaching Webster's diacritical markings to deaf students in a technical vocational college. The Webster diacritical system provides a discrete symbol for each sound and designates the appropriate syllable to be stressed in any polysyllabic word. The symbol system, therefore, presents cues for correct pronunciation, auditory discrimination, and visual recognition of new words. Both the C.A.L. and Instructional Television formats used audio-visual cues to teach the symbols for vowels, diphthongs, and the consonants--c, ng, x, and qu. The results revealed that C.A.L. was superior to Instructional Television; and that C.A.L. taught the skills without the use of the teacher. However, it was also noted that C.A.L. provided for drill and practice, review, and almost immediate recall of the course content on the post test; whereas Instructional Television did not. It was concluded that these variables, as well as the method of instruction, may have been responsible for the post test differences. Future plans envision combining both modes into a computer based interactive television system which, it is hoped, will provide greater gains in a shorter period of time.

Effectiveness of C.A.L.

C.A.L. is the newest, and most expensive, form of instructional media currently in use in education. Prior to 1970, almost all of the C.A.L. projects were conducted in university research settings. In the last few years, many schools have begun to use and research the effectiveness of C.A.L. both in general and special education. A review of the research literature indicates that there are few recorded empirical studies on the effectiveness of C.A.L. (Jamison et al., 1974; and Taylor et al., 1974).

Fletcher et al. (1972) suggested that students will attain strong and consistent achievement gains if they have C.A.L. over a reasonable portion of the school year. To support their claim, they cited sixteen studies that report C.A.L. has been used successfully in a variety of subject areas at different levels of instruction. The authors also noted that their review revealed that there were practically no negative findings in C.A.L.

Littrell (1973) concluded that the computer has the potential to be a valuable instructional tool. He observed that past research indicated that C.A.L. : (1) can be as effective or better than conventional instruction; (2) has the capability to reduce significantly instructional time; and that (3) C.A.L. is more beneficial with low achieving students. Littrell also commented that while C.A.L. had not proven to be cost effective, significant reductions in its cost seemed possible.

Jamison <u>et al</u>. (1974, pp. 55-56) suggested that a review of the research literature indicated that no uniform conclusion could be drawn about the effectiveness of C.A.L. They observed, however, that: (1) at the elementary level, C.A.L. was an effective supplement to regular instruction; (2) at the secondary level, C.A.L. was as effective as traditional instruction, when used as a replacement; (3) C.A.L. may result in substantial savings of instructional time; and (4) C.A.L. may be most beneficial when it is used by disadvantaged and slower students.

Taylor <u>et al</u>. (1974) did an extensive review of C.A.L. drill and practice programs in elementary arithmetic and language arts. Based on their review of the research, they concluded:

1. C.A.L. had proven to be an effective instructional tool.

2. When students proceeded at their own rate, they generally learned more rapidly with C.A.L. than with traditional instruction.
3. Retention of learned material did not appear to be as high with C.A.L. as compared to traditional instruction.
4. C.A.L. was effective as a form of individualized supplemental instruction.
5. C.A.L. was more effective with low ability students than with middle or high ability students.
6. Both students and teachers were highly enthusiastic about C.A.L.

Similar findings were obtained by Edwards et al. (1975) in their evaluation of the effectiveness of C.A.L.

Fletcher and Suppes (1976) concluded that C.A.L. could be used successfully by deaf students. They felt, however, that the major drawback of C.A.L. was its cost. The authors suggested that: (1) C.A.L. would continue to expand in use in schools for the deaf; (2) the quality of C.A.L. would continue to increase; and (3) the costs of C.A.L. would continue to decrease in the immediate future.

Summary

In summary, the research suggests that students do learn from programmed materials. Generally, P.I. and C.A.L. are as effective as traditional classroom instruction, and may require less time for students to achieve specific educational goals. P.I. and C.A.L. should be considered as adjuncts to the teaching system and not as replacements. P.I. used in combination with C.A.L. should enable deaf students to become independent learners and to learn more effectively.

A review of the research literature leads to the following conclusions:

1. C.A.L. is an effective educational tool;
2. C.A.L. is most effective with special education students;
3. C.A.L. reduces learning time;
4. both students and teachers have positive attitudes towards C.A.L.;
5. the costs of C.A.L. will continue to decrease which will enable it to become very cost-effective; and
6. C.A.L. soon may play an integral part in the education of all deaf children.

A primary goal in the education of children who are deaf is to provide an individualized program of instruction for every student. Computers are potentially powerful enough to individualize at many levels simultaneously. Accumulated research suggests that C.A.L. is an effective form of individualized instruction in both regular and special education. It would appear, then, that with C.A.L. one type of student who would benefit most would be deaf children who need the additional instruction and remediation, in mathematics and language arts.

CHAPTER IV

METHOD

The Problem

Regardless of which philosophy of education has been adhered to, traditional methods of instruction have not met the basic academic needs of the majority of deaf children. The poor educational achievement of deaf children throughout their school careers demands that educators of the deaf search for new and innovative methods of instruction. Research conducted in the United States suggests that deaf children can make significant grade point gains in basic arithmetic through the use of C.A.L. This research has also demonstrated that C.A.L. has resulted in increased grade point gains in the language arts areas. These latter results are encouraging, although the gains are not statistically significant. Therefore, further research is warranted to determine if C.A.L. could help severely and profoundly deaf children to enhance their educational achievement.

A main objective of this study is to evaluate the effectiveness of C.A.L. as a means of individualizing instruction for deaf children. As previously mentioned in Chapter I, this study addresses itself specifically to the following questions:

1. can drill and practice programs in mathematics and

language arts effectively reinforce skills which have been previously taught in the classroom; and

2. can C.A.L. help deaf students to retain these skills over a period of time?

Research Hypotheses

Three groups of profoundly deaf students received regular classroom instruction in arithmetic and language arts. In addition, one of the groups received C.A.L. in mathematics only, a second group received C.A.L. in language arts only, and the third group received C.A.L. in both mathematics and language arts. It is hypothesized that significance will be dependent on the number of lessons each group receives in a particular subject.

Specifically, the following null hypotheses were tested for both arithmetic and language arts achievement scores:

Null Hypothesis (1)

There will be no significant differences among the treatment effects (mean scores) of the levels of factor A (the 3 experimental group means).

Null Hypothesis (2)

There will be no significant differences among the treatment effects (means) and the levels of factor B (over time).

Null Hypothesis (3)

There will be no significant differences among the 3 experimental groups and their performance with respect to

(a) arithmetic and (b) language arts achievement scores over time.

Description of the Research Setting - The Manitoba School for the Deaf

The Manitoba School for the Deaf, in Winnipeg, is a combined day and residential school that serves the educational needs of hearing impaired children who will benefit most from a total communication approach for the development of their written and spoken English. The Manitoba School for the Deaf provides special services that are not provided by the regular public schools. The school also provides the students with medical, dental, optometric, audiological, psychological, psychiatric, and social work services.

The school population consisted of 119 students, ranging from six to twenty years of age. Forty-five students lived in the school's residence from Monday to Friday under the supervision of the Dean of Residence and ten residence counsellors. During the weekend, these students returned to their homes, which usually were in the rural areas. All other students commuted daily to and from the school either by special school bus or by Metro Transit.

There were twenty-six members on the educational staff: classroom teachers, a guidance counsellor, a home economics teacher, an industrial arts teacher, a physical education teacher, a speech teacher, and two teaching assistants. All educational personnel were under the supervision of the assistant principal and principal.

The school is ungraded; however, it is divided into three levels:

1. The Lower School consisted of 62 students, ages 6 to 14 years old, in 10 classes. In each of the Lower School classes, the classroom teacher taught all of the academic subjects, and specialists were responsible for classes in Speech, Rhythym, and Physical Education.
2. The Intermediate School contained 14 students, ages 10 to 15 years old, in 2 classes. Both classes rotated among three different teachers for their academic subjects, while classes in Speech, Rhythym, Physical Education, Guidance, Industrial Arts and Home Economics were taught by specialists.
3. The Senior School was comprised of 43 students, ages 13 to 20 years old, in 7 classes. These classes rotated to different teachers for their academic and non-academic subjects. Included in the Upper School Curriculum were the following programs: a regular academic program with the addition of Speech, Industrial Arts and Home Economics, Physical Education, and Guidance and Counselling. Vocationally oriented students attended classes at a regular public vocational school under the guidance of a full-time vocational co-ordinator. A small number of selected students

were integrated either into a public elementary school or high school on a part-time basis. These students were accompanied by a teacher of the deaf, who served as an interpreter for the students and also provided any necessary remedial tutoring.

The Sample

From the school population of 119 students, 99 students were selected to serve as Ss in the experiment. Thirteen students were under eight years of age and were excluded from the study as it is not recommended to test deaf students who are less than eight years of age (Trybus, 1975). In addition, seven students were excluded because they had a very limited command of receptive and expressive language, and therefore, could not be expected to handle the C.A.L. language arts programs.

All 99 Ss completed pretests 1 and 2 in November, 1975, and the experimental C.A.L. portion of the study. However, not all the Ss completed the post test and/or retention test phases of the study in May and June, 1976. During June, 1976, 26 students were permitted to leave school prior to the official closing of school on June 30, 1976 to seek either summer or permanent employment. These Ss did not write the post test and/or retention test. Consequently, complete statistical analyses could be performed on only 73 Ss. The following description of the sample is based on only those Ss who completed all phases of the experimental study and were included in the statistical analyses.

There were 43 boys and 30 girls in the experimental study. The Ss ranged from 8 to 18.5 years, with a mean age of 11.9 years. Seventy-one Ss were severely or profoundly deaf; that is, they had a hearing loss of 70 dB or more in the better ear across the speech range. Two Ss were moderately deaf; that is, they had a hearing loss between 55 to 69 dB in the better ear across the speech range. Thirteen Ss were multiply handicapped. In addition to their deafness, they had additional handicapping conditions, such as cerebral palsy or mental retardation, or visual disorders. These conditions significantly add to the complexity of educating a hearing impaired child (Gentile and McCarthy, 1973, p. 2).

Data obtained from the school's records were used to compute the Ss's average reading levels. The Ss reading levels ranged from a Grade Score of 1.25 to 7.50, with a mean score of 2.38. There were 9 Ss for whom reading levels were not available in the school records. A more complete descriptive profile on each student can be found in Appendix C.

The 73 Ss were assigned by their class groupings into one of three treatment groups: the language arts group; the mathematics group; or the combined language arts and mathematics group. In the Lower School, the classroom teachers were allowed to choose the treatment group for their class. The Intermediate and Senior classes were randomly assigned to one of the three treatment groups. The final treatment groupings consisted of the following numbers of school classes and numbers of students:

1. The Language Arts Group contained 6 classes, consisting

of 25 Ss from 2 Lower School classes, 1 Intermediate class, and 3 Senior School classes;

2. The Combined Language Arts and Mathematics Group contained 5 classes, consisting of 29 Ss from 3 Lower School classes, 1 Intermediate School class, and 1 Senior School class; and

3. The Mathematics Group contained 6 classes, consisting of 19 Ss from 3 Lower School, and 3 Senior classes.

Descriptive data for each treatment group is summarized in Table 3.

A t-test was calculated to ensure that the means of the three groups were not significantly different. The results of this test will be discussed in greater detail in the Limitations of the Sample section.

The treatment for the language arts group consisted of C.A.L. only in language arts programs. Language arts programs based on transformational grammar that were written particularly for deaf students were predominantly used by this group. The treatment for the mathematics group consisted of C.A.L. only in basic computational skills of addition, subtraction, multiplication, and division. The treatment for the combined language arts and mathematics group consisted of C.A.L. in both language arts programs and basic computational skills. Throughout the experimental period, all three treatment groups continued to receive regular classroom instruction in both language arts and mathematics.

TABLE 3

DESCRIPTIVE DATA FOR EACH TREATMENT GROUP

Group	Sex		Ages		Reading Level		No. of Multiply Handicapped Ss
	M	F	Range	Mean	Range	Mean	
1. Language Arts	15	10	9-17	13	1.5-7.5	2.7	1
2. Combined	17	12	8-19	11	1.3-3.5	2.1	4
3. Mathematics	11	8	8-18	12	1.7-3.6	2.3	8

Limitations of the Sample

Since the purpose of this study is to determine the effectiveness of C.A.L. drill and practice programs in mathematics and language arts for severely and profoundly deaf students, it was necessary to include as many Ss as possible to ensure the validity of comparisons between groups. However, the relatively large sample size, N=73, and the small number of computer terminals available, n=2, limited the amount of computer contact time per pupil. Each S worked at the computer terminal approximately 15 minutes 2 or 3 times per 6 day cycle.

Five Lower School classroom teachers indicated that they wanted their students to receive C.A.L. either in language arts or mathematics. Thus, these five groups were assigned to treatment groups based on teacher requests, rather than through random selection. Since there were only three remaining Lower School classes, they were assigned to the combined language arts and mathematics treatment group.

Since all the Lower School classes were not randomly assigned to treatment groups, one of the inherent dangers was that biased groups would be selected. The results of a t-test performed on the means of the pretest scores of the three elementary age treatment groups revealed that there were significant differences between the three treatment groups. In Pretest 2, the Language Arts Group obtained significantly higher mean scores than the two other treatment groups on the Word Meaning, Paragraph Meaning, and

Arithmetic subtests ($p < .05$). There were no significant differences, however, between the Combined and Mathematics groups.

Significant differences between the three treatment groups were also obtained on Pretest 1. The Language Arts group scored significantly higher mean scores than the Combined group on all three subtests ($p < .05$). The Language Arts group also scored significantly higher mean scores than the Mathematics group on the Paragraph Meaning subtest. In addition, the Mathematics group obtained higher mean scores than the Combined group on the Arithmetic subtest.

The Intermediate and Senior classes were randomly assigned to one of the three treatment groups. The results of the t-test performed on the senior Ss pretest mean scores indicated that the three treatment groups were not significantly different on the Word Meaning, Paragraph Meaning, and Arithmetic subtests. On both Pretest 1 and Pretest 2, the Language Arts group scored significantly higher mean scores than the Mathematics group on the Language subtest ($p < .05$). Similarly, the Combined group obtained higher mean scores than the Mathematics group on the Language subtest on both pretests. Reassignment at this time was not possible.

These results revealed that biased treatment groups were selected. Therefore, interpretation and generalization of the results of this study must be restricted given this limitation.

Measuring Instrument

The Stanford Achievement Test (S.A.T., 1964) was chosen to assess the Ss' achievement in the language arts and mathematics. Specifically, the Vocabulary Meaning, Paragraph Meaning, Language, and Arithmetic Computation subtests were used to evaluate the Ss' performance. This test was chosen since it was very similar to the skills that were practiced on the computer programs. All five battery levels--Primary I, Primary II, Intermediate I, Intermediate II, and Advanced--and alternate forms W, X, and Y were used during the pretests, post tests, and retention tests during the course of the study.

The S.A.T. is highly recommended by Bryan (Buros, 1965, pp. 109-24), Stake and Hastings (Buros, 1965, pp. 124-28), and Trimble (Buros, 1972, pp. 921-22) for measuring elementary-school achievement. The S.A.T., however, was developed for and standardized on a normal hearing population. Thus, the validity of the test must be questioned, when used with severely and profoundly deaf students. Since there was no other more appropriate test, and since it was so widely used both in regular public schools and schools for the deaf, the S.A.T. (1964) was felt to be appropriate for use in this study.

Each S wrote the test battery that was most appropriate to his/her age and grade level. All Ss wrote four subtests, except for those Ss who wrote the Primary I or Advanced Battery. Ss who wrote the Primary I battery did not write the Language subtest since Language was not one of the skills assessed by this battery. Similarly, Ss who wrote the Advanced battery did not write the

Vocabulary Meaning subtest, since it was not included in this battery.

Not all Ss wrote all four subtests from the same battery. Often young deaf students math abilities exceed their reading/language ability. Thus 8 Ss from the Lower School and 8 Ss from the Intermediate School wrote the Vocabulary Meaning and Paragraph Meaning subtests using the Primary I battery, but wrote the Arithmetic Computation subtest using the Primary II battery.

Table 4 illustrates the numbers of Ss and the test batteries they wrote for each of the four subtests.

Apparatus

The computer hardware consisted of a CDC6500 computer which was owned by the Manitoba Government and was located at the Cybershare Data Center in Winnipeg. Two Model 33 hardcopy teletypewriters that used a phone data set, served as the instructional terminals in the school. Two-copy Telex paper was used and provided duplicate printouts of each program. One copy of the program was kept and filed by the experimenter, while the S retained the other copy for himself/herself.

The two terminals were placed in a classroom in the Upper School. Generally, each Lower School class came to the computer room, and the teacher decided which students would work at the terminals. The other students were given seat work or individual tutoring while awaiting their turn at the terminals. The Intermediate

TABLE 4

NUMBER OF Ss WRITING THE S.A.T. SUBTESTS

	Primary I	Primary II	Intermediate I	Intermediate II	Advanced
Vocabulary Meaning	44	11	5	9	-
Paragraph Meaning	42	11	5	9	2
Language	-	3	5	9	2
Arithmetic Computation	25	26	5	9	2

and Senior School students usually were sent in pairs by the classroom teacher to work at the terminals. The experimenter's classroom was close to the computer room, and he could provide immediate assistance if technical difficulties arose while the Ss were working on the terminals.

Instructional Programs

The computer software used in this study were drill and practice programs in language arts and mathematics. Descriptions and examples of these programs can be found in Appendix D. These programs were developed by teachers and were programmed in the computer language "BASIC". The readability of the programs, especially in the language arts, was at a very low level to ensure that all Ss would understand what was expected of them.

During the study, the Lower School teachers chose the programs and the parameters for each student in her class. The experimenter, in consultation with the teachers, chose the programs and the parameters for each Intermediate and Senior School student.

Eight programs in the basics of mathematics were used in this study. Examples of each program can be found in Appendix D. A brief resume of each of these eight programs follows:

1. Countxt

   Countxt is a counting/recognition drill. Each question consists of a sequence of a randomly-chosen number of boxes and dollar signs, which the student must count. The objectives of

Countxt were:

a. to give the student practice in counting;

b. to help the student to distinguish objects; that is, to count boxes <u>or</u> dollar signs, as he must be able to differentiate between them in a sequence; and

c. to aid the student in his memory work; that is, he/she must remember how many boxes he has counted already while he skips over the dollar signs.

2. <u>Count20</u>

Count20 is a counting drill. It is a drill and practice program for young Primary level students who are just learning to count. The objectives of this program were:

a. to introduce the student to the concept of counting objects;

b. to give the students practice in counting 1 to 20 objects;

c. to help the student be aware that numbers actually correspond to real objects; and

d. to let the student practice the natural sequence of numbers.

3. <u>Addsubl</u>

Addsubl is a drill and practice program for either addition or subtraction or for a combination of both addition and subtraction. The largest sum and/or remainder can be no larger than 19. The objectives of this program were:

a. to give the student practice in addition and/or subtraction; and

b. if the range of the specified parameters is large enough, the drill will give the student practice in carrying in addition, and borrowing in subtraction.

4. <u>Missl</u>

Missl provides practice in solving equations, where one of the values of the equation is omitted. The objectives of Missl were:

a. to focus attention on the symbols used to express the concepts of addition, subtraction, and multiplication;

b. to give practice in solving equations;

c. to give practice in the inverse concept of addition to find differences;

d. to give practice in the inverse concept of subtraction to find sums;

e. to emphasize the importance of reasoning from the known to the unknown; and

f. to give practice with the commutative principle.

5. <u>Addsan</u>

Addsan is a program that provides drill in addition.

There is a choice of how many numbers (from 1 to 5) and how many digits (from 1 to 5) in each number. The objectives of Addsan were:

a. to give the student practice in adding;

b. to give the student practice in carrying; and

c. to give the student practice in adding numbers by columns.

6. Subtsan

Subtsan is a program that provides drill in subtraction. The program randomly generates problems with as many as 5 digits in the top number. The columns of numbers are arranged so that improper carrying is diagnosed immediately. The objectives of Subtsan were:

a. to provide practice in subtraction; and

b. to provide drill in borrowing.

7. Multsan

This program is a drill in multiplication. There is an option for the number of digits (from 1 to 5) in the number to be multiplied. Also, the program provides the choice of either multiplying by a fixed constant or a randomly-chosen number. There is also the option of having an extra try for each problem, or only one try. The objectives of this program were:

a. to provide drill in multiplication; and

b. to provide practice in carrying.

8. <u>Divide</u>

   Divide is a program that provides drill in division. The number of digits in the divisor and dividend is optional. Also, there is an option to include decimals. The objectives of Divide were:

   a. to drill the division of integers; and

   b. to practice the division of decimal numbers.

Five Programs based on transformational grammar as developed in the Rhode Island Language Curriculum were used frequently in the study. These programs were specifically developed for the students at the Manitoba School for the Deaf. Examples of each of these programs can be found in Appendix D. A brief description of these five programs is as follows:

1. <u>WhoWhat</u>

   This is a drill and practice program that contains 6 drills. The drills involve determining whether a noun is or is not a person, and whether the subject of simple sentence (Sentence Pattern 1) is a "who" or a "what". The objectives of WhoWhat were:

   a. to help the student to distinguish an object from a person;

   b. to introduce the use of Sentence Pattern 1;

   c. to introduce the concepts of "who" and "what" words;

   d. to give the student practice with verbs; and

e. to provide the student with practice in answering simple "who" or "what" questions.

2. Rhodel

Rhodel emphasizes analyzing sentence patterns and correct verb usage. An option provides the students with the opportunity to write good sentences through copying the sentences. The objectives of this program were:

a. to provide practice in analyzing Sentence Patterns 1 and 2;

b. to reinforce the concepts of "who" and "what" words;

c. to provide practice in correct verb usage when asking questions;

d. to provide practice in the use of adverbial phrases - "how", "when", and "where"; and

e. to provide practice in copying sentences.

3. Rhodela

Rhodela is a program that supplements Rhodel. It is intended primarily for those students who are having problems understanding the concepts "is a person", "is not a person", and "who" and "what". The objectives of this program were:

a. to provide practice in distinguishing between persons and things;

b. to provide practice in using the words "who" and "what" as being interchangeable with "is a person" or "is not a person"; and

c. to provide practice in the concept of the negation of the "be" verb; for example, choosing "is" or "is not a person".

4. Rhode2

Rhode2 also emphasizes the analysis of sentence patterns and correct verb usage. The objectives of Rhode2 were:

a. to provide practice in analyzing Sentence Patterns 3, 4, and 5;

b. to provide practice in identifying past, present, and future tenses of verbs;

c. to provide practice in simple expansions; and

d. to provide practice in copying sentences.

5. Beverbs

Beverbs is a drill and practice program that contains 6 drills. The drills involve "be" words, auxiliary verbs, and questions. The student is required to type sentences, and/or questions using proper spacing and punctuation marks. The objectives of Beverbs were:

a. to help the student to distinguish between "be" verbs and other verbs;

b. to increase the students use of sentence patterns;

c. to give the student practice with auxiliary verbs;

d. to give the student practice with sentence formation, spelling, spacing, copying and punctuation; and

e. to provide the student with practice in writing questions.

In addition a large number and variety of programs in the language arts were also used in the study. Drill and practice in language and reading was provided by programs in spelling (SpelB1, SpelA1), regular and irregular verbs (Verb1, Mread1, Mread2 and Mread3), negative verbs in the contraction form (Pair1), commonly misused pairs of words (Pair2), possessive words (Possess), pronouns (Pron3), and reading comprehension (Story1). Examples of each of these programs can be found in Appendix D.

Administration and Procedure

The study began on November 3, 1975 and continued until June 25, 1976. Originally the study was scheduled to finish on May 28, 1976; however, frequent interruptions throughout the experimental period necessitated a longer C.A.L. schedule to provide each S with as much computer contact as possible. The actual C.A.L. experimental period consisted of 24 weeks. A complete flowchart of the timetable procedure can be found in Figure 1.

FIGURE 1

FLOWCHART OF PROCEDURE FOR EXPERIMENTAL STUDY

Pretest 1
Nov. 3 - 7

Pretest 2
Nov. 10 - 14

C.A.L. SCHEDULE

Nov. 17 - 21 (1)	Feb. 23 - 27 (13)
Nov. 24 - 28 (2)	Mar. 1 - 5 (14)
Dec. 1 - 5 (3)	Mar. 8 - 12 (15)
Dec. 8 - 12 (4)	Mar. 15 - 19 (16)
Dec. 15 - 19 (5)	Mar. 22 - 26 (17)
Christmas Break Dec. 22- Jan. 2	Easter Break Mar. 29- Apr. 2
Jan. 5 - 9 (6)	Apr. 5 - 9 (18)
Jan. 12 - 16 (7)	Apr. 12 - 16 (19)
Jan. 19 - 23 (8)	Apr. 19 - 23 (20)
Jan. 26 - 30 (9)	Apr. 26 - 30 (21)
Feb. 2 - 6 (10)	May 3 - 7 (22)
Feb. 9 - 13 (11)	May 10 - 14 (23)
Feb. 16 - 20 (12)	May 17 - 21 (24)

Post Test
May 24 - 28

Retention Test
June 21 - 25

I. Pretest 1 and Pretest 2

The Ss were given two pretests approximately ten days apart from November 3 to November 14, 1975. Two pretests were used to ensure that the results were not contaminated. The tests were administered by the classroom teachers for the Lower School Ss, and by the language, maths, and reading teachers for the Intermediate and Senior School Ss. All testing was under the guidance of the experimenter. For pretest 1, Form W of the S.A.T. was used, while for pretest 2, Form X, an alternate form was used.

Each teacher, who administered a test, scored the test and converted the Ss' raw scores into grade score equivalents. The experimenter checked the raw scores and conversions for all the subtests for all Ss.

II. Computer Scheduling

C.A.L. commenced on November 17, 1975 after all Ss had completed the second subtest. During the experimental period, each S received C.A.L. in language, or mathematics or language and mathematics at least twice each six day cycle. Each C.A.L. program required approximately fifteen minutes to complete. Throughout the experimental period, the Ss received regular classroom instruction in language, maths, and reading in accordance with his/her timetable.

After the Ss had written the pretests, they were placed on a C.A.L. program associated with their test results and individual needs. The classroom teacher and/or experimenter chose the appropriate level of difficulty based on the Ss' skills and abilities.

The experimenter established a criterion score of 90% as the proficiency level for advancement to the next level of drill difficulty. It was assumed that if the S scored 90%, he demonstrated a mastery of the concepts and skills at that drill level of the program. Johnson and Kress (1975, pp. 5-7) view the 90% proficiency level as an independent level of achievement. It is, therefore, reasonable to assume that in this study 90% is not too rigorous as a criterion level of proficiency. Rather it reflects an independent understanding of the material at hand.

During the experimental period, volunteers assisted the Ss, if necessary, to "log-on" and "log-off" the computer terminals. They also served to remediate any difficulties that occurred while the Ss worked at their programs. All volunteers were given explicit instructions neither to assist nor prompt the Ss while they worked at their drill programs. Generally, the volunteers were high school students, college students and parents of the students.

The Ss were very familiar with C.A.L., since it had been introduced into the school in May, 1974. In addition, the Ss were given two months of C.A.L. just prior to the experimental study. It could be safely assumed that the Ss were no longer responding to the novelty of C.A.L. As a result, the study was able to control for the Hawthorne Effect.

III. Post Test and Retention Test

The post test was administered during the week of May 24-28, and the retention test was given three weeks later during the week of June 21-25. The tests were administered by the same teachers who had administered the pretests. Again, all testing was under the guidance of the experimenter. For the post test, Form Y of the S.A.T. was used, while for the retention test, Form W was used.

The tests were scored and converted to grade score equivalents by the teachers who had administered the post test and retention test. All the raw scores and conversions for all the subtests for all Ss were checked by the experimenter. Then the statistical analyses were computed.

STATISTICAL PROCEDURE

Analysis of Variance for Repeated Measures Over Time

The tests for significant differences over time using the repeated measures of pretest (1), pretest (2), post test and retention test raw scores for arithmetic and language arts were performed using the Analyses of Variance for Mixed Designs Program.

The statistical analyses consisted of seven separate 3 x 4 analysis of variance designs for repeated measures over time. Analyses of Variance were performed separately on elementary age Ss and senior age Ss for both arithmetic and language arts scores. A diagram of the data treatment design can be found in Appendix E.

The following are the statistical hypotheses for arithmetic and language arts using the Analysis of Variance for Repeated Measures (3 x 4 design). A more comprehensive discussion of derivations and formulae can be found in Winer (1971) Chapter 4.

1. Null Hypothesis

$$H_o = \alpha_1 = \alpha_2 = \alpha_3 = 0$$

There will be no significant differences among the treatment effects (mean scores) of factor A (treatment group means).

Alternative Hypothesis

$$H_1 = \text{not } H_o$$

There will be significant differences among the treatment effects of factor A.

2. Null Hypothesis

$$H_o = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$$

There will be no significant differences in mean achievement scores among the treatment groups.

Alternative Hypothesis

$$H_1 = \text{not } H_o$$

There will be significant differences in mean achievement scores among the treatment groups.

3. Null Hypothesis

$$H_1 = \alpha_1\beta_1 = \alpha_1\beta_2 = \alpha_1\beta_3 = \alpha_1\beta_4 = \alpha_2\beta_1 \ldots \alpha_3\beta_4 = 0$$

There will be no significant differences among the

3 treatment groups and their performance with respect to (a) arithmetic and (b) language arts scores over a period of time.

Alternative Hypothesis

$$H_1 = \text{not } H_o$$

There will be significant differences among the 3 treatment groups and their performance with respect to (a) arithmetic and (b) language arts scores over a period of time.

Post Hoc Tests

After the results of the Analyses of Variance were examined, two a posteriori multiple comparison tests were used to determine where the significant differences occurred.

I. Scheffé

The Scheffé method was used to determine whether the significant differences occurred between: (1) group 1, the language arts group and group 2, the combined language arts and mathematics group, or (2) group 1, the language arts group and group 3, the mathematics group or (3) group 2 and group 3. Since the Scheffé procedure is more rigorous than other procedures, Ferguson (1971, p. 271) recommends that significant differences be compared at the .10 level.

II. Newman-Keuls

The Newman-Keuls probing technique was used to determine whether significant differences existed between pretests, post test, and/or retention tests. Winer, (1971, pp. 77-85) states that with unequal sample sizes it is best to use treatment means rather than treatment totals. Thus, using this method, the following treatment means were compared:

Ho		H_1
$\overline{X}_1 = \overline{X}_2$ (pre 1 = pre 2)	or	$\overline{X}_1 \neq \overline{X}_2$
$\overline{X}_1 = \overline{X}_3$ (pre 1 = post)	or	$\overline{X}_1 \neq \overline{X}_3$
$\overline{X}_1 = \overline{X}_4$ (pre 1 = ret.)	or	$\overline{X}_1 \neq \overline{X}_4$
$\overline{X}_2 = \overline{X}_3$ (pre 2 = post)	or	$\overline{X}_2 \neq \overline{X}_3$
$\overline{X}_2 = \overline{X}_4$ (pre 2 = ret.)	or	$\overline{X}_2 \neq \overline{X}_4$
$\overline{X}_3 = \overline{X}_4$ (post = ret.)	or	$\overline{X}_3 \neq \overline{X}_4$

Significant differences were compared between pretests (1 and 2), post test, and retention tests at the .05 and .01 levels.

Test for Simple Main Effects

Further analyses of the results were carried out by means of the test for simple main effects. If the AB interaction of factors A (treatments) and B (time) is significant, it is standard procedure to test for simple main effects. Since this investigation revealed significant interaction for one of the language arts scores for elementary age Ss and one language arts score for senior Ss, all at the .05 level, tests for simple main effects were performed.

Analysis of Covariance for Repeated Measures

The results of the Analyses of Variance revealed that the overall results between groups were inconsistent. Consequently, the Analysis of Covariance was also used to test for significant differences over time for the post test scores. Pretest 1 and pretest 2 were used as covariates. Two Analyses of Covariance with repeated measures were performed separately for elementary Ss and senior Ss on four dependent variables. The repeated measures were the four dependent variables: word meaning, paragraph meaning, arithmetic and language scores. The two pretests scores were used to covary with the post test scores.

INTERCORRELATIONS

Intercorrelations between (1) pretests 1 and 2, and post test, and (2) pretests 1 and 2 and retention test were calculated for arithmetic and language arts scores for descriptive purposes. These results will indicate whether the increased scores, if any, may be attributed to overall treatment effects.

CHAPTER V

RESULTS

The results of the study are presented in this chapter. A discussion of the results in relation to the hypotheses will be found in the discussion section of the thesis.

The raw data tables are found in Appendix F. The scores are represented in the form of grade point scores (years/months). The means, variances, and standard deviations are found also in Appendix F. In addition, the cell means in summary table form appear in Appendix G.

As stated in Chapter Four, the three main Null Hypotheses for the Analyses of Variance for word meaning, paragraph meaning, language, and arithmetic were:

1. there will be no significant differences among the treatment means;
2. there will be no significant differences in mean achievement scores among the treatment groups; and
3. there will be no significant differences among the 3 experimental groups and their performance with respect to (a) arithmetic and (b) language arts achievement scores over time.

Analysis of Variance for Word Meaning

I. Elementary Ss

The summary table for the Analysis of Variance for word meaning for elementary Ss can be found in Table 5. For Hypothesis 1, the critical value needed for significance at the .01 level was 5.18 (df = 2,36). The F ratio was significant at the .01 level. The computed F ratio reveals that there was a significant difference among the means of the levels of factor A, but it does not tell us where the difference is. An a posteriori probing procedure is needed to determine where the difference lies. The Null Hypothesis was rejected, therefore, and the Alternate Hypothesis was accepted.

The critical value for Hypothesis 2 at the .01 level was 3.95 (df = 3,108). The F ratio was significant at the .01 level. The computed F ratio reveals that there was a significant difference among the means of the levels of factor B. Another a posteriori probing procedure is required to determine where the difference lies. Null Hypothesis 2 was rejected and the Alternate Hypothesis was accepted.

For Hypothesis 3, the critical value needed for significance at the .01 level was 2.96 (df = 6,108). The computed F ratio was significant at the .01 level, which indicated a significant interaction effect. Null Hypothesis 3 was rejected, therefore, and the Alternate Hypothesis was accepted.

TABLE 5

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Elementary Ss-Word Meaning)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	8.71	2	4.35	11.69 **
Subj. w groups	13.41	36	0.37	
B (Word Scores)	2.68	3	0.89	19.14 **
AB	0.83	6	0.14	2.97 **
BX subj. w groups	5.05	108	0.05	
TOTALS	31.69	155		

* $p < .05$

** $p < .01$

II. Senior Ss

The summary table for the Analysis of Variance for word meaning for senior Ss can be found in Table 6. For Hypothesis 1, the critical value needed for significance at the .05 level was 3.35 (df = 2,27). There was no significant difference among the 3 experimental groups means. Thus, Null Hypothesis 1 was accepted.

The critical value for Hypothesis 2 at the .01 level was 3.95 (df = 3,81). The F ratio was significant at the .01 level. The computed F ratio reveals that there was a significant difference among the means of the levels of factor B. An a posteriori probing technique is required to determine where the difference lies. Null Hypothesis 2 was rejected and the Alternate Hypothesis was accepted.

For Hypothesis 3, the critical value needed for significance at the .05 level was 2.17 (df = 6,81). The calculated F ratio revealed that there was no significant interaction. Therefore, Null Hypothesis 3 was accepted.

Analysis of Variance for Paragraph Meaning

I Elementary Ss

The summary table for the Analysis of Variance for paragraph meaning for elementary Ss can be found in Table 7. For Hypothesis 1, the critical value needed for significance at the .01 level was 5.39 (df = 2,34). The F ratio was significant at the .01 level, which indicated that there was a significant difference among the means of the levels of factor A. Null Hypothesis 1 was rejected, therefore, and the Alternate Hypothesis was accepted.

TABLE 6

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Senior Ss-Word Meaning)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	13.10	2	6.55	1.28
Subj. W groups	138.17	27	5.12	
B (Word Scores)	3.10	3	1.03	8.26 **
AB	0.74	6	0.12	0.99
BX subj. w groups	10.12	81	0.12	
TOTALS	164.33	119		

* $p < .05$

** $p < .01$

TABLE 7

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Elementary Ss-Paragraph Meaning)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	6.97	2	3.49	13.74 **
Subj. w groups	8.63	34	0.25	
B (Paragraph Mean.)	0.18	3	0.06	3.02 *
AB	0.22	6	0.04	1.89
BX subj. w groups	2.00	102	0.02	
TOTALS	18.56	147		

* $p < .05$
** $p < .01$

The critical value for Hypothesis 2 at the .05 level was 2.68 (df = 3,102). The computed F ratio was significant at the .05 level, which indicated that there was a significant difference among the means of the levels of factor B. Null Hypothesis 2 was rejected and the Alternate Hypothesis was accepted.

For Hypothesis 3, the critical value needed for significance at the .05 level was 2.17 (df = 6,102). The computed F ratio revealed that there was no significant interaction. Therefore, Null Hypothesis 3 was accepted.

II Senior Ss

The summary table for the Analysis of Variance for paragraph meaning for senior Ss can be found in Table 8. For Hypothesis 1, the critical value needed for significance at the .05 level was 3.33 (df = 2,29). There was no significant difference among the 3 experimental group means. Therefore, Null Hypothesis 1 was accepted.

The critical value for Hypothesis 2 at the .05 level was 2.76 (df = 3,87). There was no significant difference among the means of the levels of factor B over time. Therefore, Null Hypothesis 2 was accepted.

For Hypothesis 3, the critical value needed for significance at the .05 level was 2.25 (df = 6,87). The computed F ratio revealed that there was no significant interaction. Therefore, Null Hypothesis 3 was accepted.

TABLE 8

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Senior Ss-Paragraph Meaning)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	17.60	2	8.80	1.33
Subj. w groups	191.67	29	6.61	
B (Paragraph Mean.)	0.43	3	0.14	0.97
AB	1.75	6	0.29	1.96
BX subj. w groups	12.96	87	0.15	
TOTALS	226.24	127		

* $p < .05$
** $p < .01$

Analysis of Variance for Arithmetic

I Elementary Ss

The summary table for the Analysis of Variance for arithmetic for elementary Ss can be found in Table 9. For Hypothesis 1, the critical value needed for significance at the .01 level was 5.39 (df = 2,34). The F ratio was significant at the .01 level, which indicated that there was a significant difference among the means of the levels of factor A. Null Hypothesis 1 was rejected, therefore, and the Alternate Hypothesis was accepted.

The critical value for Hypothesis 2 at the .01 level was 3.95. The computed F ratio was significant at the .01 level, which indicated that there was a significant difference among the means of the levels of factor B. Null Hypothesis 2 was rejected and the Alternate Hypothesis was accepted.

For Hypothesis 3, the critical value needed for significance at the .05 level was 2.17 (df = 6,102). The computed F ratio revealed that there was no significant interaction. Therefore, Null Hypothesis 3 was accepted.

II Senior Ss

The summary table for Analysis of Variance for arithmetic for senior Ss can be found in Table 10. For Hypothesis 1, the critical value needed for significance at the .05 level was 3.32 (df = 2,30). There was no significant difference among the 3 experimental group means. Therefore, Null Hypothesis 1 was accepted.

TABLE 9

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Elementary Ss-Arithmetic)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	19.20	2	9.60	8.30 **
Subj. w groups	39.31	34	1.15	
B (Math Scores)	3.61	3	1.20	17.41 **
AB	0.41	6	0.07	0.98
BX subj. w groups	7.06	102	0.07	
TOTALS	71.47	147		

* $p < .05$

** $p < .01$

TABLE 10

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Senior Ss-Arithmetic)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F Ratio
A (Treatment)	30.18	2	15.09	0.83
Subj. w groups	548.21	30	18.27	
B (Math Scores)	12.27	3	4.09	9.34 **
AB	1.34	6	0.22	0.51
BX subj. w groups	39.39	90	0.44	
TOTALS	632.12	131		

* $p < .05$

** $p < .01$

The critical value for Hypothesis 2 at the .01 level was 3.95 (df = 3,90). The computed F ratio was significant at the .01 level, which indicated that there was a significant difference among the means of the levels of factor B. Null Hypothesis 2 was rejected, therefore, and the Alternate Hypothesis was accepted.

For Hypothesis 3, the critical value needed for significance at the .05 level was 2.17 (df = 6,90). The computed F ratio revealed that there was no significant interaction. Therefore, Null Hypothesis 3 was accepted.

Analysis of Variance for Language

Senior Ss

The summary table for Analysis of Variance for language for senior Ss can be found in Table 11. For Hypothesis 1, the critical value needed for significance at the .05 level was 3.63 (df = 2,16). There was no significant difference among the 3 experimental group means. Thus, Null Hypothesis 1 was accepted.

The critical value for Hypothesis 2 at the .01 level was 4.31 (df = 3,48). The computed F ratio was significant at the .01 level, which indicated that there was a significant difference among the means of the levels of factor B. Null Hypothesis 2 was rejected, therefore, and the Alternate Hypothesis was accepted.

For Hypothesis 3, the critical value needed for significance at the .01 level was 3.29 (df = 6,48). The computed F ratio was significant at the .01 level, which indicated a significant interaction effect. Therefore, Null Hypothesis 3 was rejected, and the Alternate Hypothesis was accepted.

TABLE 11

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Senior Ss-Language)

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares	F Ratio
A (Treatment)	77.52	2	38.76	3.06
Subj. w groups	202.75	16	12.67	
B (Language Scores)	3.54	3	1.18	8.42 **
AB	2.77	6	0.46	3.30 **
BX subj. w groups	6.73	48	0.14	
TOTALS	314.92	75		

* $p < .05$

** $p < .01$

For more descriptive information, the cell means for ANOVA can be found in Appendix G.

Post Hoc Tests

I. Scheffé

Significant differences were found among the 3 experimental group means of factor A for elementary Ss in word meaning, paragraph meaning, and arithmetic. The Scheffé probing technique was used to determine where the differences occurred. The data for this test can be found in Tables 12, 13, and 14 for word meaning, paragraph meaning and arithmetic respectively.

In this method, the means of the levels of A are arranged in rank order from low to high. Differences between the pairs of means are computed. F ratios ($F = t^2$) and F' values are calculated from the formulae:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\dfrac{Sw^2}{m_1} + \dfrac{Sw^2}{m_2}}} \qquad \text{and } F' = (k-1)\,F$$

For any difference to be significant at the required level, F must be greater than or equal to F' (Ferguson, 1971, pp. 270-71). Since the Scheffé procedure is more rigorous than other procedures, Ferguson (1971, p. 271) recommends that significant differences be compared at the .10 level. The pairs of means which can be considered different are indicated by asterisks.

TABLE 12

MULTIPLE COMPARISONS OF TREATMENT MEANS

USING THE SCHEFFÉ PROCEDURE

(Elementary Ss-Word Meaning)

	a_2 (Combined)	a_3 (Maths)	a_1 (Language)
Ordered Means	1.69	1.74	2.24

	a_2	a_3	a_1
a_2		F = 0.13 (F′ = 4.70)	F = 15.44 (F′ = 4.70)
a_3			F = 12.74 (F′ = 4.70)
a_1			—

	a_2 Combined	a_3 Maths	a_1 Language
(a_2) Combined		--	**
(a_3) Maths			**

* $p < .10$
** $p < .05$

TABLE 13

MULTIPLE COMPARISONS OF TREATMENT MEANS

USING THE SCHEFFÉ PROCEDURE

(Elementary Ss-Paragraph Meaning)

	a_2 (Combined)	a_3 (Maths)	a_1 (Language)
Ordered Means	1.60	1.61	2.08

	a_2	a_3	a_1
a_2		F = 0.01 (F′ = 4.70)	F = 28.41 (F′ = 4.70)
a_3			F = 18.23 (F′ = 4.70)
a_1			—

	(a_2) Combined	(a_3) Maths	(a_1) Language
(a_2) Combined		--	**
(a_3) Maths			**

* $p < .10$
** $p < .05$

TABLE 14

MULTIPLE COMPARISONS OF TREATMENT MEANS

USING THE SCHEFFÉ PROCEDURE

(Elementary Ss-Arithmetic)

	a_2 (Combined)	a_3 (Maths)	a_1 (Language)
Ordered Means	1.45	1.78	2.33
	a_2	a_3	a_1
a_2		$F = 4.24$ ($F' = 4.70$)	$F = 19.36$ ($F' = 4.70$)
a_3			$F = 6.25$ ($F' = 4.70$)
a_1			—

	a_2 Combined	a_3 Maths	a_1 Language
(a_2) Combined		--	**
(a_3) Math			**

* $p < .10$
** $p < .05$

Elementary Ss

1. Word Meaning

In Table 12 significant differences at the .05 level were found between (1) the language arts (a_1), and the combined language arts - maths (a_2) groups, and (2) between the language arts (a_1) and maths (a_3) groups.

2. Paragraph Meaning

The data of Table 13 reveals significance at the .05 level between (1) the language arts and combined groups, and (2) the language arts and maths groups.

3. Arithmetic

Significant differences at the .05 level were found between (1) the language arts and combined groups and (2) the language arts and maths groups in Table 14.

II. Newman-Keuls

Significant differences were found among the levels of factor B (over time) for elementary Ss in word meaning, paragraph meaning, and arithmetic scores. In addition, significant differences for senior Ss were obtained in word meaning, arithmetic and language scores. The Newman-Keuls probing technique was used to determine where the differences occurred.

The data for the Newman-Keuls test for elementary Ss can be found in Tables 15 to 17 for word meaning, paragraph meaning and arithmetic respectively. The data for senior Ss can be found in

TABLE 15

TEST ON MEANS USING NEWMAN-KEULS PROCEDURE

(Elementary Ss-Word Meaning)

		b_2	b_1	b_3	b_4
Ordered Means		1.75	1.77	2.00	2.04
		b_2	b_1	b_3	b_4
(i)	b_2		.02	.25	.29
	b_1			.23	.27
	b_3				.04
(ii)	$q_{.95}$ (r,108)		2.80	3.36	3.68
	$q_{.99}$ (r,108)		3.70	4.20	4.50
(iii)	$S_{\bar{B}}q_{.95}$ (r,108)		.11	.13	.15
	$S_{\bar{B}}q_{.99}$ (r,108)		.15	.17	.18
		Pre (2)	Pre (1)	Post Test	Retention
(iv)	Pre (2)		—	**	**
	Pre (1)			**	**
	Post Test				—

* $p < .05$

** $p < .01$

TABLE 16

TEST ON MEANS USING NEWMAN-KEULS PROCEDURE

(Elementary Ss-Paragraph Meaning)

			b_2	b_1	b_3	b_4
Ordered Means			1.71	1.76	1.78	1.80
			b_2	b_1	b_3	b_4
(i)	b_2			.05	.07	.09
	b_1				.02	.04
	b_3					.02
(ii)	$q_{.95}$	$(r,102)$		2.80	3.36	3.68
	$q_{.99}$	$(r,102)$		3.70	4.20	4.50
(iii)	$S_{\bar{B}}q_{.95}$	$(r,102)$		.06	.07	.07
	$S_{\bar{B}}q_{.99}$	$(r,102)$		.07	.08	.09

		Pre (2)	Pre (1)	Post Test	Retention
(iv)	Pre (2)		—	*	**
	Pre (1)				—
	Post Test				—

* $p < .05$

** $p < .01$

TABLE 17

TEST ON MEANS USING NEWMAN-KEULS PROCEDURE

(Elementary Ss-Arithmetic)

		b_2	b_1	b_3	b_4
Ordered Means		1.66	1.75	1.95	2.06
		b_2	b_1	b_3	b_4
(i)	b_2		.09	.29	.40
	b_1			.20	.31
	b_3				.11
(ii)	$q_{.95}$ (r,102)		2.80	3.36	3.68
	$q_{.99}$ (r,102)		3.70	4.30	4.50
(iii)	$S_{\bar{B}}q_{.95}$ (r,102)		.11	.13	.15
	$S_{\bar{B}}q_{.99}$ (r,102)		.15	.17	.18
		Pre (2)	Pre (1)	Post Test	Retention
(iv)	Pre (2)		—	**	**
	Pre (1)			**	**
	Post Test				—

* $p < .05$

** $p < .01$

Tables 18 to 20 for word meaning, arithmetic and language respectively.

In this technique, the means of the levels of B are arranged in rank order from low to high. Then differences between pairs of the means are computed. In part (iii) the critical values for the ordered differences between pairs are computed, and they are compared to the differences in ordered means (i). If (i) is greater than, or equal to (iii) then there is a significant difference.

1. Elementary Ss

In Table 15 for word meaning, levels of significance at the .01 level were found between pretest (2) and post test and retention test; and between pretest (1) and post test and retention test.

In Table 16 for paragraph meaning, levels of significance at the .01 level were found between pretest (2) and retention test. At the .05 level, significance was obtained between pretest (2) and post test.

In Table 17 for arithmetic, levels of significance at the .01 level were found between pretest (2) and post test and retention test; and between pretest (1) and post test and retention test.

2. Senior Ss

In Table 18 for word meaning, levels of significance at the .01 level were found between pretest (2) and retention test and post test; and between pretest (1) and post test.

TABLE 18

TEST ON MEANS USING NEWMAN-KEULS PROCEDURE

(Senior Ss-Word Meaning)

			b_2	b_1	b_4	b_3
Ordered Means			2.92	2.99	3.22	3.31
			b_2	b_1	b_4	b_3
(i)	b_2			.07	.30	.39
	b_1				.23	.32
	b_4					.09
(ii)	q.95	(r,81)		2.83	3.40	3.74
	q.99	(r,81)		3.76	4.28	4.59
(iii)	$S_{\bar{B}}q.95$	(r,81)		.17	.20	.22
	$S_{\bar{B}}q.99$	(r,81)		.23	.26	.28
			Pre (2)	Pre (1)	Retention	Post Test
(iv)	Pre (2)			—	**	**
	Pre (1)				*	**
	Retention					—

* $p < .05$

** $p < .01$

TABLE 19

TEST ON MEANS USING NEWMAN-KEULS PROCEDURES

(Senior Ss-Arithmetic)

		b_2	b_1	b_3	b_4
Ordered Means		4.07	4.37	4.77	4.82
		b_2	b_1	b_3	b_4
(i)	b_2		.30	.70	.75
	b_1			.40	.45
	b_3				.05
(ii)	$q_{.95}$ (r,90)		2.80	3.36	3.68
	$q_{.99}$ (r,90)		3.70	4.20	4.50
(iii)	$S_{\bar{B}}q_{.95}$ (r,90)		.34	.40	.44
	$S_{\bar{B}}q_{.99}$ (r,90)		.44	.50	.54
		Pre (2)	Pre (1)	Post Test	Retention
(iv)	Pre (2)		—	**	**
	Pre (1)			*	*
	Post Test				—

* $p < .05$

** $p < .01$

TABLE 20

TEST ON MEANS USING NEWMAN-KEULS PROCEDURES

(Senior Ss-Language)

			b_2	b_3	b_1	b_4
Ordered Means			3.80	4.17	4.21	4.40
			b_2	b_3	b_1	b_4
(i)	b_2			.37	.41	.60
	b_3				.04	.23
	b_1					.19
(ii)	$q_{.95}$	(r,48)		.26	.31	.34
	$q_{.99}$	(r,48)		.34	.39	.42
(iii)	$S_{\bar{B}}q_{.95}$	(r,48)		.26	.31	.34
	$S_{\bar{B}}q_{.99}$	(r,48)		.34	.39	.42
			Pre (2)	Post Test	Pre (1)	Retention
(iv)	Pre (2)			**	**	**
	Post Test				—	—
	Pre (1)					—

* $p < .05$

** $p < .01$

At the .05 level, significance was obtained between pretest (1) and retention test.

In Table 19 for arithmetic, levels of significance at the .01 level were found between pretest (2) and post test and retention test. At the .05 level, significance was obtained between pretest 1 and post test and retention test.

In Table 20, levels of significance at the .01 level were found between pretest 2 and post test, and pretest 1 and retention test.

III. Test for Simple Main Effects

Tests for simple main effects were performed in order to determine if there are differences between:

1. a_1, a_2, and a_3 at b_1 or
   a_1, a_2, and a_3 at b_2 or
   a_1, a_2, and a_3 at b_3 or
   a_1, a_2, and a_3 at b_4.
2. b_1, b_2, b_3, and b_4 at a_1 or
   b_1, b_2, b_3, and b_4 at a_2 or
   b_1, b_2, b_3, and b_4 at a_3.

A clarification of letters a_1, a_2, b_1, et cetera for the data treatment design can be found in Appendix E.

1. Elementary Ss

The results for elementary Ss for word meaning are shown in

Table 21. An analysis of the data indicates a significant difference among treatment effects for pretest 2, post test and retention test at the .01 level. Both the language arts and combined language arts-maths groups showed significant differences over time at the .01 level, and a significant interaction at the .05 level. Therefore, the Null Hypothesis that there is no significant difference in the effects of factor A can be rejected at levels b_2, b_3, and b_4 (pretest 2, post test, and retention test, respectively). Also, the Null Hypothesis that there is no significant difference in the effects of factor B (time) when observations are made at levels a_1 (language arts group) and a_2 (combined group) is rejected.

2. Senior Ss

The results for senior Ss for language are shown in Table 22. Data analysis indicates a significant difference among treatment effects of pretest 1, pretest 2, post test and retention test at the .05 level. Both the language arts and combined groups showed significant differences over time at the .05 and .01 levels, respectively, and significant interaction at the .01 level. Therefore, the Null Hypothesis that there is no significant difference in the effects of factor A can be rejected at levels b_1, b_2, b_3, and b_4. Also, the Null Hypothesis that there is no significant difference in the effects of factor B (time) when observations are made at levels a_1 and a_2 is rejected.

TABLE 21

ANALYSIS OF VARIANCE FOR SIMPLE MAIN EFFECTS

(Elementary Ss-Word Meaning)

Source	SS	df	MS	F
1. Between subjects				
2. Between A at b_1	0.74	2	0.37	$(\frac{2}{6})$ = 2.85
3. Between A at b_2	2.64	2	1.32	$(\frac{3}{6})$ = 10.23 **
4. Between A at b_3	3.95	2	1.98	$(\frac{4}{6})$ = 15.23 **
5. Between A at b_4	3.08	2	1.54	$(\frac{5}{6})$ = 11.85 **
6. Within Cell	18.46	144	0.13	
7. Within subjects				
8. Between B at a_1 (language arts group)	2.45	3	0.82	$(\frac{8}{12})$ = 16.40 **
9. Between B at a_2 (combined group)	0.95	3	0.32	$(\frac{9}{12})$ = 6.40 **
10. Between B at a_3	0.28	3	0.09	$(\frac{10}{12})$ = 1.80
11. AB	0.83	6	0.14	$(\frac{11}{12})$ = 2.80 *
12. BX Subj. W. groups	5.05	108	0.05	

* $p < .05$; F critical = 3.07 (df = 2,144); 2.69 (df = 3,108); 2.71 (df = 6,108)

** $p < .01$; F critical = 4.79 (df = 2,144); 3.95 (df = 3,108); 2.96 (df = 6,108)

TABLE 22

ANALYSIS OF VARIANCE FOR SIMPLE MAIN EFFECTS

(Senior Ss-Lanugage)

Source	SS	df	MS	F
1. Between subjects				
2. Between A at b_1	28.72	2	14.36	$(\frac{2}{6}) = 4.39$ *
3. Between A at b_2	25.19	2	12.60	$(\frac{3}{6}) = 3.85$ *
4. Between A at b_3	28.00	2	14.00	$(\frac{4}{6}) = 4.28$ *
5. Between A at b_4	20.69	2	10.35	$(\frac{5}{6}) = 3.17$ *
6. Within Cell	209.48	64	3.27	
7. Within subjects				
8. Between B at a_1 (language arts group)	1.24	3	0.41	$(\frac{8}{12}) = 2.93$ *
9. Between B at a_2 (combined group)	2.86	3	0.95	$(\frac{9}{12}) = 6.79$ **
10. Between B at a_3	1.14	3	0.38	$(\frac{10}{12}) = 2.71$
11. AB	2.77	6	0.46	$(\frac{11}{12}) = 3.29$ **
12. BX Subj. W. groups	6.73	48	0.14	

* $p < .05$; F critical = 3.15 (df = 2,64); 2.84 (3,48); 2.34 (df = 6,48)

** $p < .01$; F critical = 4.98 (df = 4,98); 4.31 (3,48); 3.29 (df = 6,48)

Analysis of Covariance for Repeated Measures

1. Elementary Ss

The summary table for the Analysis of Covariance for Repeated Measures for elementary Ss can be found in Table 23. Pretest 1 and pretest 2 were used as covariates. The computed F value for factor G indicated that there were significant differences among the means of the dependent variables at the 0.001 level. The remaining computed F values were not significant at either the .05 or .01 levels. The significant difference among the means of the three subtests were consistent with expectations because of the differences in the scaled scores on the subtests.

2. Senior Ss

The summary table for the Analysis of Covariance for Repeated Measures for senior Ss can be found in Table 24. None of the computed F values were significant at either the .05 or .01 levels.

Further tests using the results of the Analysis of Covariance were not carried out, since the overall results revealed a lack of significance for both the elementary Ss and senior Ss.

IV. Intercorrelations

For descriptive purposes, the intercorrelations were calculated for elementary Ss, senior Ss and total Ss for the word meaning, paragraph meaning and arithmetic subtests. In addition, the intercorrelations for senior Ss for the language subtest were calculated.

TABLE 23

ANALYSIS OF CONVARIANCE SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Elementary Ss)

Source of Variation	SS	DF	MS	F	LEVEL
Mean	55.15	1	55.15	5.62	0.02
G (dependent variables)	159.06	2	79.53	8.11	0.001 **
H (groups)	9.23	2	4.61	0.47	0.63
GH	21.94	4	5.49	0.56	0.69
1st covar. (pretest 1)	251.41	1	251.41	25.63	
2nd covar. (pretest 2)	205.65	1	205.65	20.97	
All Covariates	1962.22	2	981.11	100.03	
Error	1000.38	102	9.81		

* $p < .05$

** $p < .01$

TABLE 24

ANALYSIS OF VARIANCES SUMMARY TABLE

FOR REPEATED MEASURES DESIGN

(Senior Ss)

Source of Variation	SS	DF	MS	F	LEVEL
Mean	160.02	1	160.02	2.89	0.09
G (dependent variables)	360.85	3	120.28	2.17	0.10
H (groups)	201.79	2	100.89	1.82	0.17
GH	171.74	6	28.62	0.52	0.79
1st covar. (pretest 1)	993.99	1	993.99	17.94	
2nd covar. (pretest 2)	435.76	1	435.76	7.87	
All Covariates	25700.21	2	12850.11	231.94	
Error	5429.52	98	55.40		

* $p < .05$

** $p < .01$

The results of the correlation data indicated that pretests to retention tests were highly correlated and significant at the .05 and .01 levels for all four subtests. When the elementary and senior groups are compared, the correlation data revealed that there was greater stability of scores from pretests to retention tests on all three subtests for the senior _Ss_ group. The results of the correlation matrices are found in Table 25 for Word Meaning, Table 26 for Paragraph Meaning, Table 27 for Arithmetic, and Table 28 for Language.

In each subtest, the group mean scores for all three treatment groups, for both elementary _Ss_ and senior _Ss_, are represented graphically in Figures 2 to 8.

TABLE 25

CORRELATION MATRICES FOR WORD MEANING

Elementary Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.69**	1.00		
3 (post)	0.71**	0.86**	1.00	
4 (ret)	0.75**	0.73**	0.84**	1.00

* $p < .05$ r critical = .32 df (37)
** $p < .01$ r critical = .41 df (37)

Senior Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.90**	1.00		
3 (post)	0.91**	0.90**	1.00	
4 (ret)	0.91**	0.94**	0.94**	1.00

* $p < .05$ r critical = .36 df (28)
** $p < .01$ r critical = .46 df (28)

Total Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.93**	1.00		
3 (post)	0.93**	0.93**	1.00	
4 (ret)	0.92**	0.93**	0.95**	1.00

* $p < .05$ r critical = .24 df (65)
** $p < .01$ r critical = .31 df (65)

TABLE 26

CORRELATION MATRICES FOR PARAGRAPH MEANING

Elementary Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.87**	1.00		
3 (post)	0.86**	0.76**	1.00	
4 (ret)	0.85**	0.85**	0.91**	1.00

* $p < .05$ r critical = .32 df (35)

** $p < .01$ r critical = .41 df (35)

Senior Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.94**	1.00		
3 (post)	0.93**	0.91**	1.00	
4 (ret)	0.93**	0.93**	0.89**	1.00

* $p < .05$ r critical = .34 df (30)

** $p < .01$ r critical = .44 df (30)

Total Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.95**	1.00		
3 (post)	0.95**	0.93**	1.00	
4 (ret)	0.95**	0.94**	0.93**	1.00

* $p < .05$ r critical = .24 df (65)

** $p < .01$ r critical = .31 df (65)

TABLE 27

CORRELATION MATRICES FOR ARITHMETIC

Elementary Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.90**	1.00		
3 (post)	0.93**	0.85**	1.00	
4 (ret)	0.87**	0.88**	0.92**	1.00

* $p < .05$ r critical = .32 df (35)

** $p < .01$ r critical = .41 df (35)

Senior Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.97**	1.00		
3 (post)	0.97**	0.95**	1.00	
4 (ret)	0.87**	0.86**	0.92**	1.00

* $p < .05$ r critical = .34 df (31)

** $p < .01$ r critical = .44 df (31)

Total Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.98**	1.00		
3 (post)	0.98**	0.96**	1.00	
4 (ret)	0.92**	0.92**	0.95**	1.00

* $p < .05$ r critical = .23 df (66)

** $p < .01$ r critical = .30 df (66)

TABLE 28

CORRELATION MATRICES FOR LANGUAGE

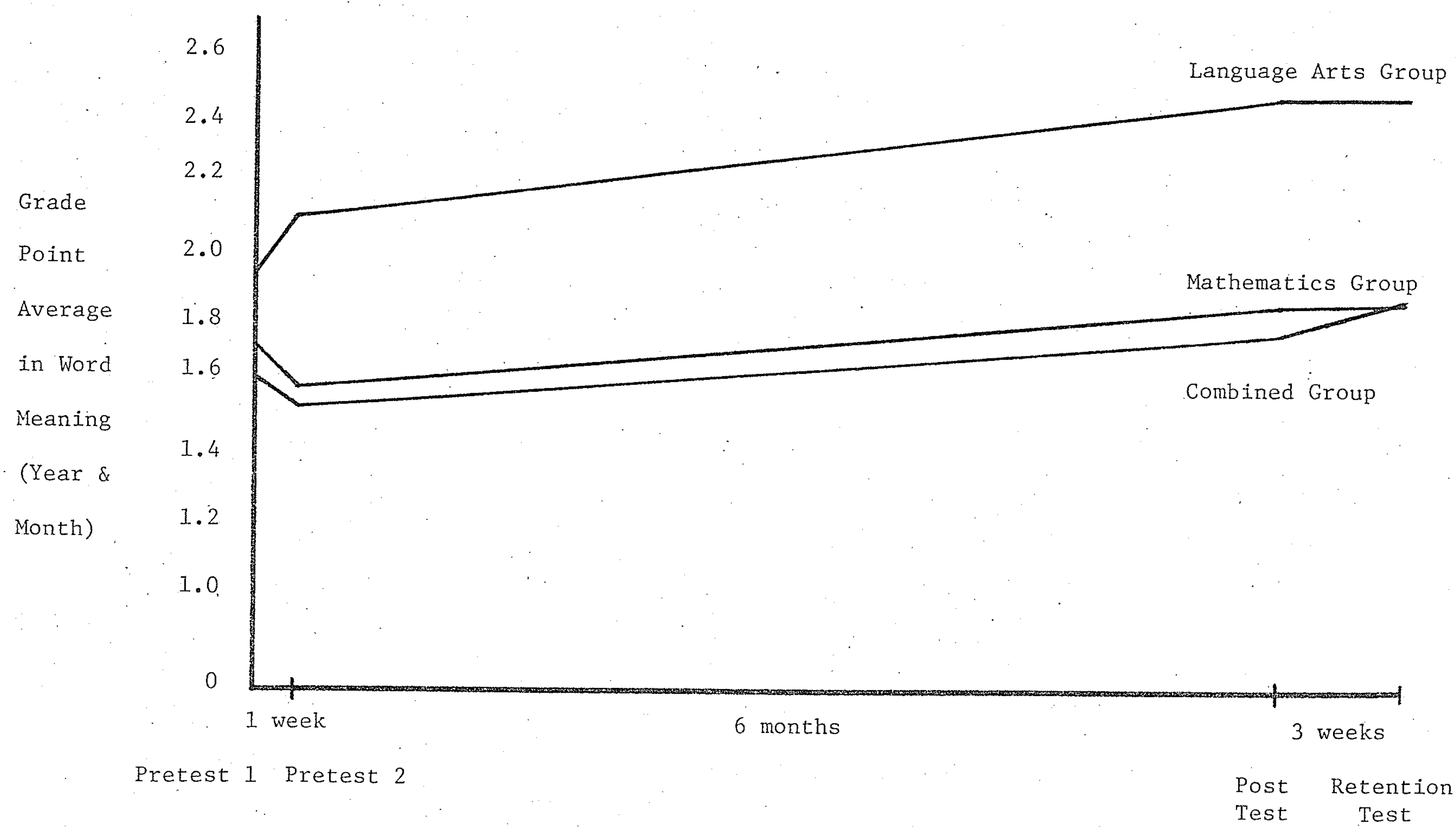
Senior Ss

	1 (pre 1)	2 (pre 2)	3 (post)	4 (ret)
1 (pre 1)	1.00			
2 (pre 2)	0.95**	1.00		
3 (post)	0.97**	0.96**	1.00	
4 (ret)	0.98**	0.94**	0.95**	1.00

* $p < .05$ r critical = .45 df (17)

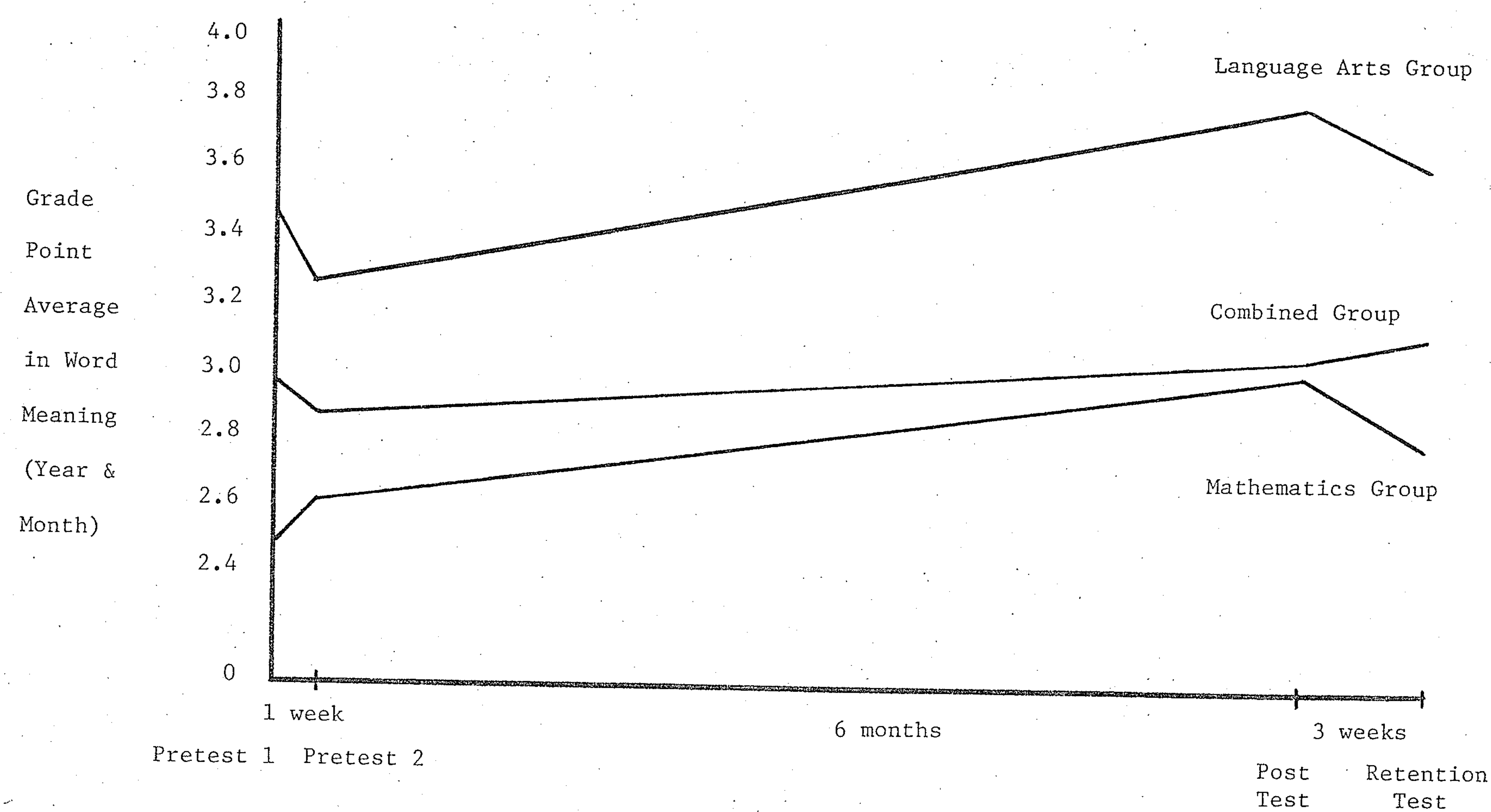
** $p < .01$ r critical = .57 df (17)

FIGURE 2



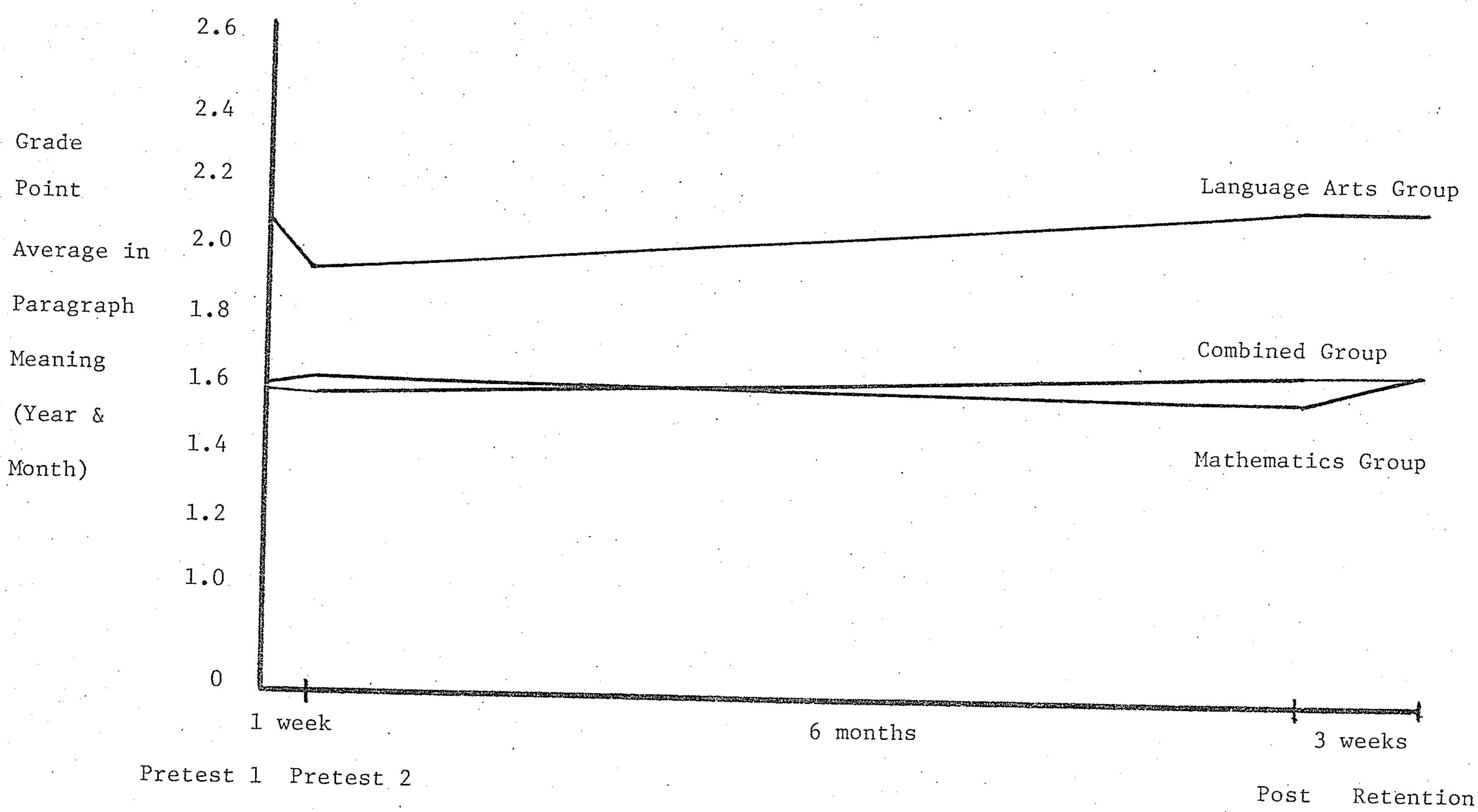
Mean Scores in Word Meaning for Elementary Ss Over a Period of Seven Months

FIGURE 3



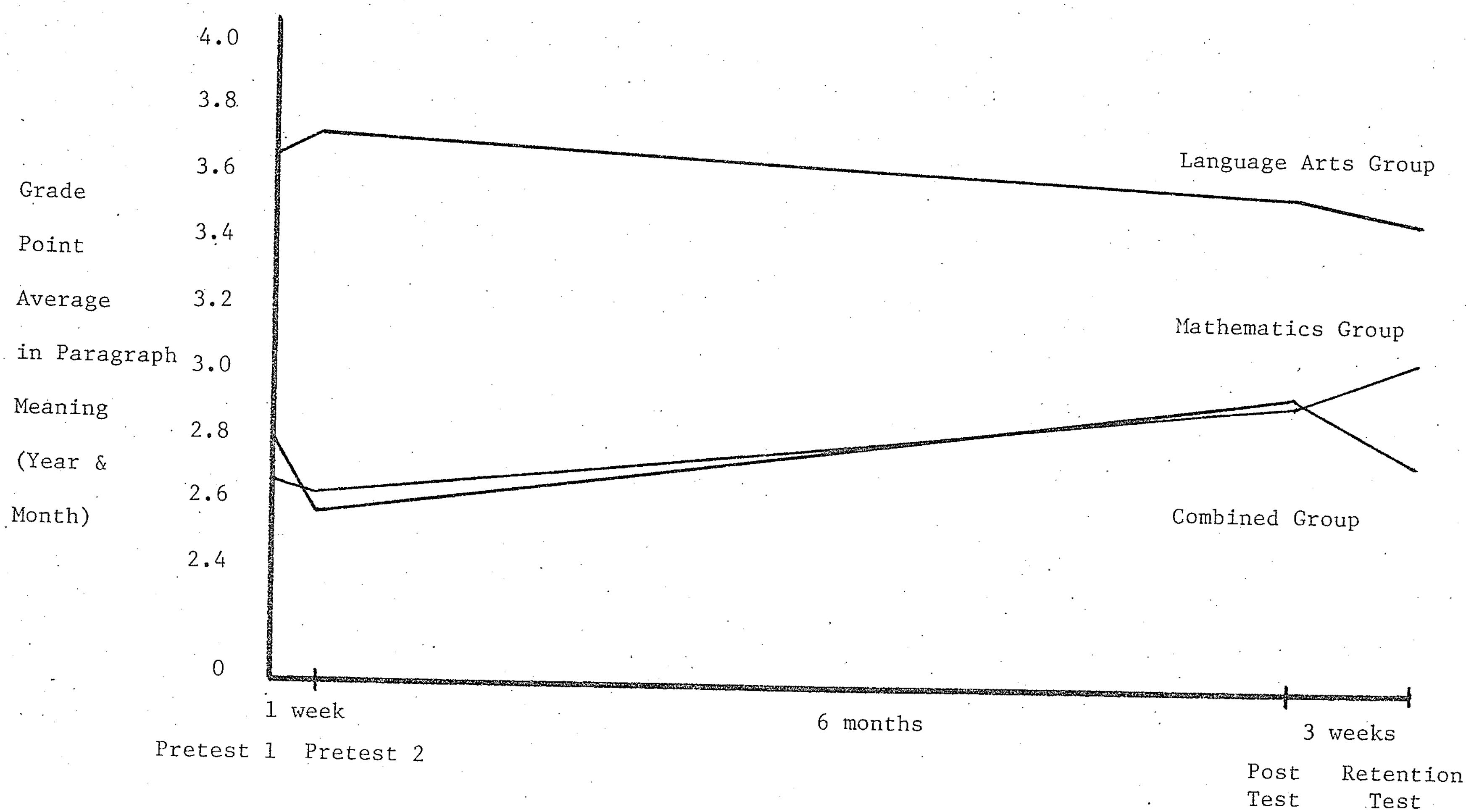
Mean Scores in Word Meaning for Senior Ss Over a Period of Seven Months

FIGURE 4



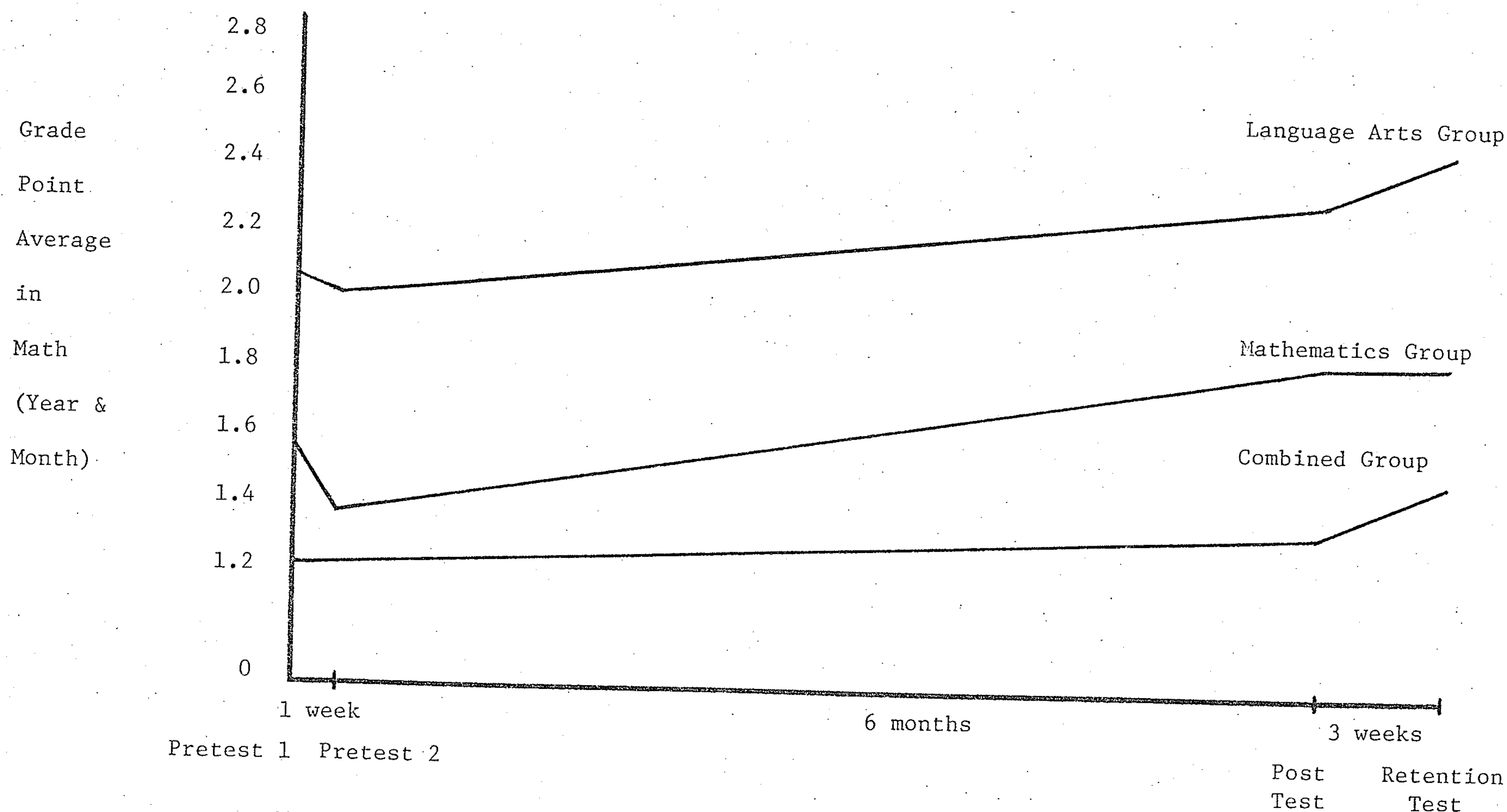
Mean Scores in Paragraph Meaning for Elementary <u>Ss</u> Over a Period of Seven Months

FIGURE 5



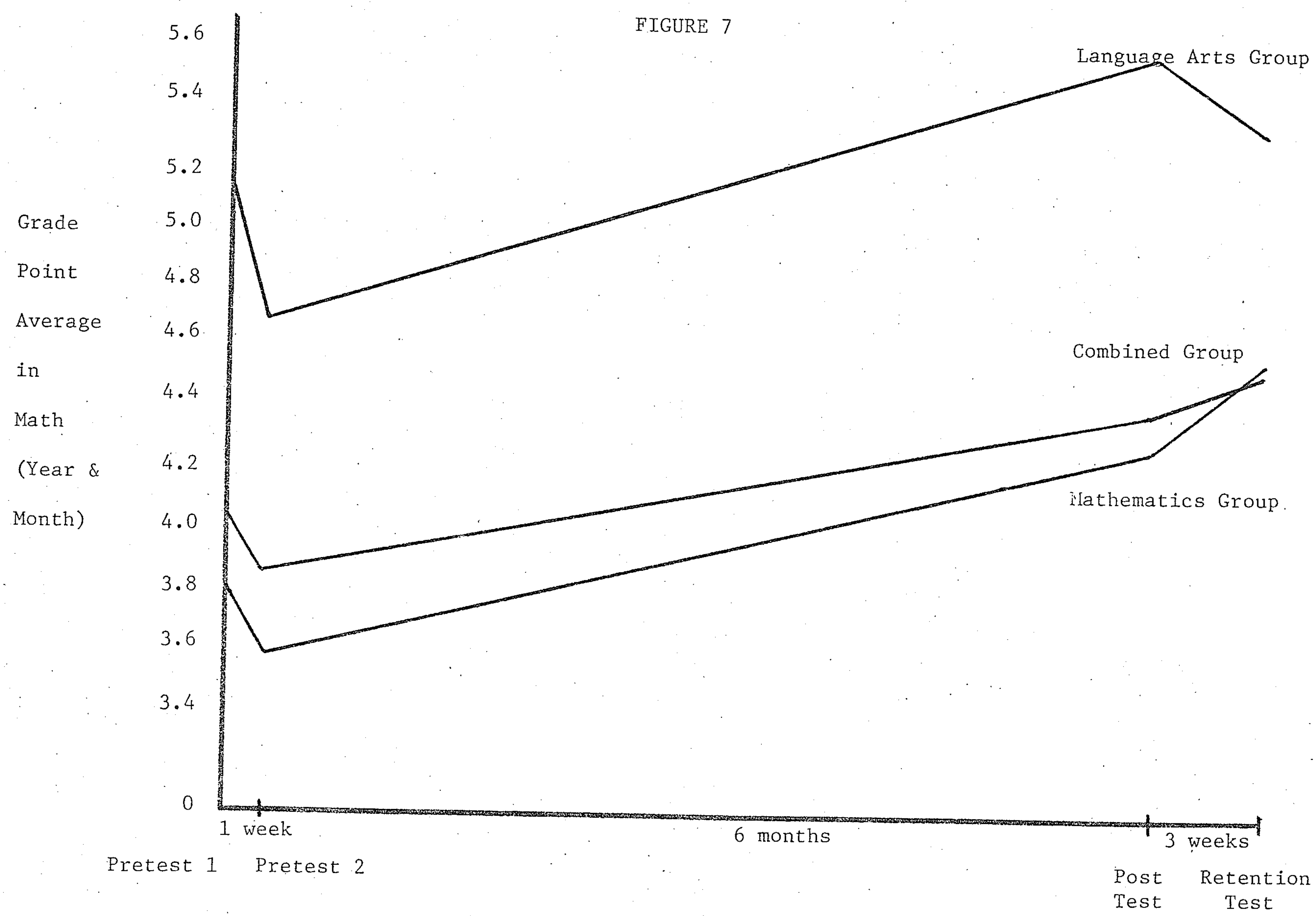
Mean Scores in Paragraph Meaning for Senior <u>Ss</u> Over a Period of Seven Months

FIGURE 6



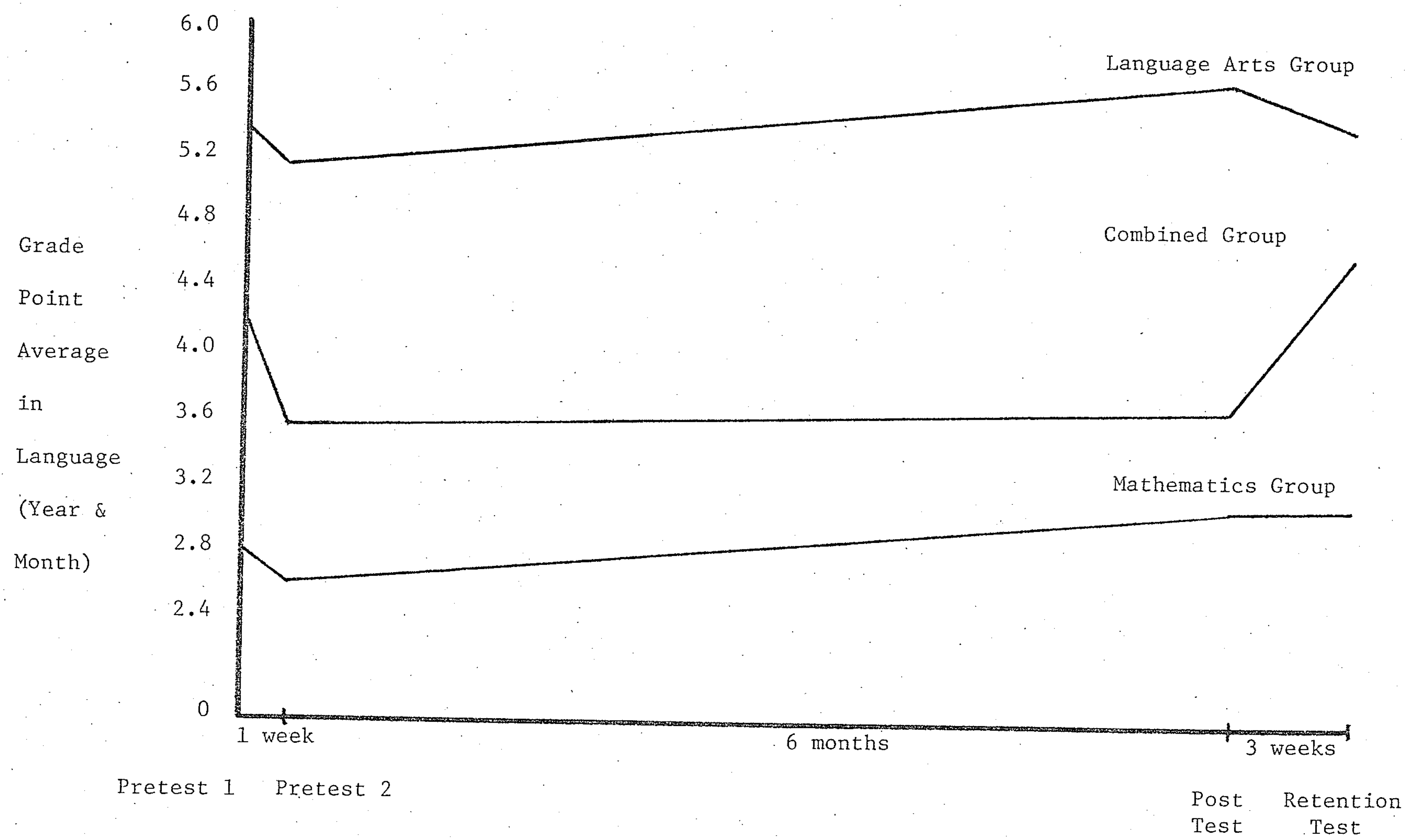
Mean Scores in Math for Elementary Ss Over a Period of Seven Months

FIGURE 7



Mean Scores in Math for Senior Ss Over a Period of Seven Months

FIGURE 8



Mean Scores in Language for Senior Ss Over a Period of Seven Months

CHAPTER VI

DISCUSSION AND CONCLUSIONS

The findings of this study have demonstrated that: (1) severely and profoundly deaf students were able to work independently at the computer terminal, and (2) C.A.L. is a practical means of reinforcing the academic skills of deaf students.

Analysis of Variance for Word Meaning

I. Elementary Ss

Since there was a significant difference among the experimental groups due to treatment effects, Null Hypothesis (1) was rejected, and the Alternate Hypothesis for elementary Ss for word meaning was accepted. The Scheffé probing procedure was used to determine where the significant differences occurred. Results of this test indicated significant differences at the .05 level between (1) the language arts group and the combined group, and (2) the language arts group and the maths group. There was no significant difference between the maths group and the combined group. These results indicated that significant gains in word meaning were made by the language arts group, which received the greatest amount of supplementary C.A.L. language arts instruction. These results were consistent with expectations.

The Analysis of Variance revealed a significant difference over time; therefore, Null Hypothesis (2) was rejected and the Alternate

Hypothesis was accepted. Results of the Newman-Keuls probing technique revealed significant differences between: (1) pretest 2 and the post test and retention tests; and (2) between pretest 1 and the post test and retention tests. Both differences were significant at the .01 level. These results suggest that vocabulary learning, as measured by the word meaning subtest, occurred during the experimental period.

The results obtained with respect to Null Hypothesis (3) showed a significant interaction effect. Thus, Null Hypothesis (3) was rejected; and the Alternate Hypothesis, that there were significant differences among the treatment effects over time, was accepted. Accordingly, tests for simple main effects were performed.

Results of the tests for simple main effects indicated significant differences over time for treatment effects between pretest 2, post test and retention test. Although significance was found at the post test and retention test levels, these results were confounded by the significance shown at pretest 2. The reason for the confounding significance at the pretest 2 level was felt to be due to biased experimental groups. This will be discussed in more depth later in this chapter.

The results of the tests for simple main effects also revealed that both the language arts group and the combined group showed significant interaction at the .05 level. The maths group did not show any significance at the .05 level. Thus, both groups which received supplementary C.A.L. in language obtained significantly larger gains in word meaning that the maths group, which did not receive supplementary C.A.L. in language. These results were consistent with expectations.

II. Senior Ss

Since no significant differences were found among the experimental group means, Null Hypothesis (1) for senior Ss for word meaning was accepted.

The Analysis of Variance revealed a significant difference over time; therefore, Null Hypothesis (2) was rejected and the Alternate Hypothesis was accepted. Results of the Newman-Keuls probing procedure revealed significance at the .01 level between: (1) pretest 2 and the retention test and post tests, and (2) between pretest 1 and the post test. At the .05 level, significance was obtained between pretest 1 and the retention test. These results suggest that vocabulary learning, as measured by the word meaning subtest, occurred during the experimental period.

The results obtained for Null Hypothesis (3) revealed no significant interaction effect at either the .05 or .01 levels. Thus, Null Hypothesis (3) for word meaning for senior Ss was accepted. The lack of significance may be due to the large variability of scores. The students' S.A.T. word meaning scores ranged from grade point level 1.7 to 8.5. Significance was difficult to achieve with such a large variability of scores and with a relatively small sample.

Analysis of Variance for Paragraph Meaning

I. Elementary Ss

Since there was a significant difference among the experimental groups due to treatment effects, Null Hypothesis (1) was rejected and the Alternate Hypothesis for elementary Ss for paragraph meaning was accepted. Results of the Scheffé probing procedure revealed significant differences at the .05 level between: (1) the language arts and combined group, and (2) between the language arts and maths group. There was no significant difference between the maths group and the combined group. These results replicate the findings for word meaning for elementary Ss. These findings indicated that significant gains in paragraph reading were made by the language arts group, which received the greatest amount of supplementary C.A.L. language arts instruction. These results were consistent with expectations.

The Analysis of Variance revealed a significant difference over time; therefore, Null Hypothesis (2) was rejected and the Alternate Hypothesis was accepted. Results of the Newman-Keuls probing technique showed significance between: (1) pretest 2 and the retention test at the .01 level, and (2) between pretest 2 and the post test at the .05 level. However, these results were confounded since no significant differences were obtained between pretest 1 and the post test and retention tests. These latter results suggest that no significant gains in paragraph reading occurred during the experimental period.

The results obtained with respect to Null Hypothesis (3) revealed no significant interaction effect at either the .05 or .01 levels. Thus, Null Hypothesis (3) for paragraph meaning for elementary Ss was accepted.

II. Senior Ss

Since no significant differences were found among the experimental group means, Null Hypothesis (1) for senior Ss for paragraph meaning was accepted.

The Analysis of Variance revealed no significant difference over time; therefore, Null Hypothesis (2) was accepted.

The results obtained for Null Hypothesis (3) revealed no significant interaction effect at either the .05 or .01 levels. Thus, Null Hypothesis (3) for paragraph meaning was accepted.

There are several explanations for the lack of significance for paragraph meaning for senior Ss. First, there was an insufficient number of C.A.L. language arts programs appropriate for the diverse needs of senior age Ss. Second, past research has revealed that reading comprehension is the academic subject most severely affected by deafness (DiFrancesca and Carey, 1972, p. vi). Related to this is the severity of the students' hearing loss. Students who have severe or profound hearing losses usually obtain their poorest achievement scores on reading comprehension tests (DiFrancesca, 1972, p. 9). The majority of students in this study had either severe or profound hearing losses. Finally, this situation is further complicated since deaf students generally score their smallest achievement gains, usually in tenths of one year, during their adolescent years (Moores, 1970, p. 37). Given these considerations, it is not surprising that there was a lack of significance for paragraph meaning for senior Ss in the present study.

Analysis of Variance for Arithmetic

I. Elementary Ss

Since there was a significant difference among the experimental groups due to treatment effects, Null Hypothesis (1) was rejected and the Alternate Hypothesis for elementary Ss for arithmetic was accepted. Results of the Scheffé probing procedure revealed significant differences at the .05 level between: (1) the language arts group and the combined group, and (2) between the language arts group and the maths group. There was no significant difference between the maths group and the combined group. The significant difference between the language arts group and the maths group, in favor of the language arts group, was inconsistent with expectations. These results suggest that the language arts group was superior to the two other experimental groups. This was due to the selection of biased experimental groups. The lack of significance between the maths group and the combined group may have been due to the lack of sufficient computer contact time during the experimental period. Each S worked at the computer terminal approximately 15 minutes, 2 or 3 times per 6 day cycle. Current research indicates that C.A.L. is most beneficial when the students work at the computer terminals for a brief time each day. However, in the present study it was not possible to provide every S with the opportunity to work at the terminals daily since there were only two terminals available.

The Analysis of Variance revealed a significant difference over time; therefore, Null Hypothesis (2) was rejected and the Alternate Hypothesis was accepted. Results of the Newman-Keuls probing technique showed significance at the .01 level between: (1) pretest 2 and the post test and retention tests; and (2) between pretest 1 and the post test and retention tests. These results suggest that learning in arithmetic occurred during the experimental period.

The results obtained with respect to Null Hypothesis (3) revealed no significant interaction effect at either the .05 or .01 levels. Thus, Null Hypothesis (3) for arithmetic for elementary Ss was accepted.

II. Senior Ss

Since no significant differences were found among the experimental group means, Null Hypothesis (1) for senior Ss for arithmetic was accepted.

The Analysis of Variance revealed a significant difference over time; therefore, Null Hypothesis (2) was rejected and the Alternate Hypothesis was accepted. Results of the Newman-Keuls probing technique revealed significant differences at the .01 level between pretest 2 and the post test and retention tests. At the .05 level, significance was found between pretest 1 and the post test and retention tests. These results suggest that learning in arithmetic occurred during the experimental period.

The results obtained for Null Hypothesis (3) revealed no significant interaction effect at either the .05 or .01 levels. The lack of significance may be due to the large variability of arithmetic scores, which ranged from grade point level 1.5 to 12.6. Significance was difficult to achieve with such a large variability of scores with a small sample.

Analysis of Variance for Language

Senior Ss

Since no significant differences were found among the experimental group means, Null Hypothesis (1) for senior Ss for language was accepted.

The Analysis of Variance revealed a significant difference over time; therefore, Null Hypothesis (2) was rejected and the Alternate Hypothesis was accepted. Results of the Newman-Keuls probing procedure revealed significant differences, at the .01 level between pretest 2 and the post test, pretest 1, and the retention tests. Since the post test scores were smaller than the pretest 1 scores, it was impossible to derive any meaningful generalization regarding the significance of the data.

The results obtained with respect to Null Hypothesis (3) showed a significant interaction effect. Thus Null Hypothesis (3) was rejected; and the Alternate Hypothesis, that there were significant differences among the treatment effects over time, was accepted. Accordingly, tests for simple main effects were performed.

The results of the tests for simple main effects revealed that both the language arts group and the combined group showed significant interaction at the .01 level. The maths group did not show any significance at either the .05 or .01 levels. Thus, both groups which received supplementary C.A.L. in language obtained significantly greater gains in language than the maths group, which did not receive supplementary C.A.L. in language. However, it was not possible to derive any generalizations from the data, since the combined group showed significance at the .01 level, while the language arts group showed significance only at the .05 level. This was not consistent with expectations.

Analysis of Covariance for Repeated Measures

The general results of the Analysis of Covariance for Repeated Measures revealed a lack of significance for both the elementary Ss and senior Ss. Only one computed F value revealed statistical significance. This statistical significance, which was consistent with expectations, was obtained among the means of the three subtests for elementary Ss. The scores of the three subtests--word meaning, paragraph meaning, and arithmetic--are scaled scores, and therefore, differences among the means of the three subtests were expected. Since the results of the Analysis of Covariance for Repeated Measures revealed a lack of overall significance, further tests were not carried out.

Intercorrelations

The results of the correlation data indicated that gains in achievement were quite consistent during the experimental period.

However, when the elementary and senior groups were compared, the correlations revealed that the scores of the senior Ss showed greater stability from pretests to retention tests on all three subtests. This was not surprising since deaf students' achievement scores tend to plateau during their adolescent years, and so there was less variability in their scores. The converse is true, however for young deaf students. Thus, the correlations for elementary Ss reflect the variability of their scores. In general, there was a tendency for the scores on the subtests to decline slightly from pretest 1 to pretest 2. This result may have been due to the use of alternate forms of the Stanford Achievement Test (S.A.T.) on pretest 1 and pretest 2.

In general, the results of this study did not show statistical significance. Since biased treatment groups were used, any statistical significance that was obtained was confounded by this factor. Therefore, it is not possible to derive any meaningful generalizations, or to predict any trends from the experimental data.

General Comment

Previous research has demonstrated that C.A.L. can be an effective supplement to conventional classroom instruction. Although statistical significance was not obtained in this study, several important observations were noted throughout the experimental period which have relevant educational implications.

Shortly after the experimental period commenced, it became evident that the majority of the students were capable of "logging-on" and "logging-off" the computer terminals by themselves. Many of the teachers were quite surprised that even the youngest students could be independent, and did not require much assistance. This suggests that teachers often underestimate the abilities of their students, and perhaps do not encourage them to work independently.

One benefit of C.A.L. has been the heightened awareness of many of the teachers of the importance of individualizing instruction for their students. As the experimental period progressed, it became clear that many of the teachers were using C.A.L. to strengthen skill areas as well as reinforce concepts that had been previously taught in the classroom. However, it is this experimenter's opinion that the potential of C.A.L. to individualize instruction was not always being utilized to its maximum capability. This may have been due to the teachers' inexperience and/or inadequate training in how to diagnose and prescribe individual programs of study. Inservice training in diagnosis and prescription and greater exposure to C.A.L. would enable teachers to use C.A.L. more effectively.

The use of C.A.L. also resulted in time efficiency. Generally, the students worked much faster and often with greater accuracy on the computer than in the classroom. This was especially true in mathematics. The same maths program required fifteen minutes to complete on the computer terminal, but required thirty minutes or more to complete in the classroom.

The time efficiency factor of C.A.L. also improved the students' attention span and concomitantly, their ability to attend to the learning situation. A general complaint among teachers of the deaf is the students' inability and/or unwillingness to attend to the learning situation. The typical classroom setting provides many distractors for the students, which often results in an inefficient teaching-learning process. However, the C.A.L. drill and practice programs were highly motivating and focused the students' attention. This resulted in an improved learning environment.

In addition, many teachers observed that the students displayed a positive attitude towards C.A.L. The students, particularly the young students, worked enthusiastically at the terminals. Several students, who often showed a negative attitude towards learning in the classroom, found C.A.L. to be stimulating and enjoyable.

Another benefit of C.A.L. is that it can provide deaf students with a "quality-quantity" approach in their language learning. That is, the computer can provide the students with thousands of examples of grammatically correct sentences. It is probable that the majority of deaf students in North America currently are receiving either a "quality" or "quantity" approach in their language learning, but very few are receiving both. The need for a combined approach is obvious.

C.A.L. has also resulted in several other benefits. Many of the students in the study learned how to use the telephone and to type. Both of these skills are essential in the use of the teletypewriter telephones (T.T.Y.) which deaf people use to communicate with each other.

Implications and Future Considerations

The general results of this study suggest that C.A.L. is a practical means of reinforcing the academic skills of deaf students. Drill and practice, when presented in the classroom, is boring and uninspiring. But when it is presented in a C.A.L. format, the students found it stimulation and challenging. The information gained during this study suggested that improvements were needed in several areas. These changes would provide future studies with a strengthened experimental model from which more specific conclusions could be drawn.

Foremost, additional C.A.L. language arts programs need to be written. Topics for these new programs should include: negation, conjunction, question formation, pronominalization, complementation, relativization, and passive voice. Research by Russell, Quigley, and Power (1976) indicates that these are the linguistic constructions that hearing impaired students have the most difficulty in mastering. These new programs, in addition to the current programs, need to be developed in a hierarchy of skill development. Although a start has been made to develop a hierarchy of skills and programs, many gaps exist, and these must be filled before any future research in language arts in undertaken.

Additional mathematical programs that involve word problems need to be developed, at both the lower and upper elementary levels. Such programs would further reinforce and develop the reading, thinking and computational skills of deaf students.

In this study, each subject worked at the computer usually every second or third day since only two terminals were available. This limited the amount of computer contact time for each subject throughout the experimental period. In future studies with C.A.L., better results might be obtained if the subjects work at the computer for fifteen minutes daily for six to eight months. This could enable significant gains to occur in both language arts and mathematics.

Other C.A.L. studies in the future could go beyond the usual comparison with conventional classroom instruction. For example, control groups could receive drill and practice in mathmatical computation using hand digital calculators. Language arts lessons taught in the classroom could be reinforced through the use of C.A.L. interfaced with slides, video tapes and television. Such multi-media experimentation would greatly enhance our understanding of the effectiveness of educational technology and its feasibility with deaf students.

Future C.A.L. studies that involve deaf students could also consider program development in non-academic and social skills such as: money management, nutrition, personal hygiene, consumer education, and vocational-career development. Computer assisted diagnostic testing also could become an integral part of a C.A.L. program. This would provide information on the students' entry behaviors and program performance, which would lead to further diagnosis, prescription and remedial strategies.

Limitations of the Study

The selection of biased treatment groups precluded any meaningful conclusions and generalizations from the experimental data. The experimenter was able to gain the cooperation, support and participation of some of the teachers in this study by allowing them to select the C.A.L. treatment condition for their students, rather than by random assignment of treatment conditions. This procedure significantly weakened the experimental model of this study. Future C.A.L. studies with deaf students should adhere to the scientific model by randomly selecting the subjects and randomly assigning them to the treatment conditions. Such a procedure would ensure that relevant conclusions and generalizations could be drawn from the data.

The use of different parallel forms, W, X, and Y of the Stanford Achievement Test (S.A.T.) was also a limitation of this study. Brill (1974, pp. 173-177) states that the use of different parallel forms of the same test, at the beginning and end of a learning period, will not provide a true measure of what deaf students have learned. Brill advises that the same test form must be administered both at the beginning and at the end of a learning period in order to measure the deaf student's progress. It follows, therefore, that the use of three parallel test forms in this study did not provide a real measure of the learning that occurred during the experimental C.A.L. period.

The validity of the use of the S.A.T. (1964) used with the deaf students in this study must also be questioned. This test was designed for and standardized on a normal hearing population, and thus has limited use with deaf students. Test levels of the S.A.T. are ordinarily assigned to the students on the basis of their school grade placement. However, this is inappropriate with deaf children, since grade level designations do not reflect their academic ability; rather they usually indicate the number of years the children have attended school. A Special Edition for Hearing Impaired Students of the S.A.T. (1973) has been recently published. This Special Edition was not used in this study as it was not available when this study commenced. This test was developed and standardized on a large sample of hearing impaired students in the United States. This Special Edition of the S.A.T. would appear to be more suitable for deaf children since the content and the difficulty level were selected independently for each subtest area. This is especially important in the reading and mathematics areas, since deaf students abilities on these two subtests are very disparate. In addition, national norms for hearing impaired students, according to age have been developed with the Special Edition. It is recommended that future studies using C.A.L. with deaf students use the Special Edition of the S.A.T. since it would appear to be more appropriate.

In this study, C.A.L. might have been more effective if there had been closer supervision of the types of C.A.L. programs selected for the students. Often, many of the students in a class would work at one program, all using the same parameters. Improved liason between the experimenter and teachers would have ensured better coordination between classroom instruction and related C.A.L. topics for each student. In addition, inservice training in the preparation of individualized programs of study should have been provided for the teachers prior to the commencement of this study. Better program selection and closer evaluation of the students' progress throughout the experimental period might have enhanced the effectiveness of C.A.L.

Volunteers were an invaluable aid in the proctoring and monitoring of the system and the students as they worked at the terminals. However, the effectiveness of C.A.L. also might have been improved if there had been only one proctor, who would have performed these duties on a full time basis. Such a person would have been able to provide more consistent supervision, and better coordination between the experimenter and the teachers. It must be emphasized, however, that the volunteers in this study enabled the project to run quite efficiently.

Summary and Conclusions

The selection of biased treatment groups and the use of different alternate forms of the S.A.T. confounded the experimental data of this study. These limitations negated any statistical significance that was obtained from the data. Consequently, it is not possible to derive any meaningful generalizations or to predict any significant trends from the experimental data *per se*.

The results of this study, however, are educationally relevant to teachers and researchers. This study has demonstrated that C.A.L. is feasible with profoundly deaf students. The majority of the students demonstrated that they are capable of using the system with very little assistance. Teachers observed that C.A.L. is stimulating and challenging to the students, and a practical means to strengthen skill areas and reinforce concepts that have been previously taught in the classroom, both in the mathematics and language arts. As teachers become more skillful in individualizing their instruction and coordinating C.A.L. with their teaching, the effectiveness of C.A.L. will increase accordingly.

In conclusion, the use of the computer as an instructional tool is increasingly becoming a viable method of instruction. Its future in the education of deaf children seems especially bright. As more programs are developed in academic, non-academic and social skill areas, researchers will have greater scope to investigate its efficacy and diversity in the education of children who are profoundly deaf.

REFERENCES

Alterman, A.I. Language and the Education of Children with Early Profound Deafness. <u>American Annals of the Deaf</u>, 1970, 115 (5), 514-521.

Atkinson, R.C., Fletcher, J.D., Lindsay, E.J., Campbell, J.D., and Barr, A. Computer Assisted Instruction in Initial Reading: Individualized Instruction Based on Optimization Procedures. <u>Educational Technology</u>, 1973, 13 (9), 27-37.

Atkinson, R.C. and Wilson, H.A., Eds. <u>Computer Assisted Instruction: A Book of Readings</u>. New York: Academic Press, 1969.

Bachor, Patricia. A Study of Some Aspects of Computer Assisted Language Instruction. Unpublished Master's Thesis, University of Calgary, 1973.

Barnes, D.O. and Finkelstein, A. The Role of Computer Assisted Instruction at the National Technical Institute for the Deaf. <u>American Annals of the Deaf</u>, 1971, 116 (5), 466-468.

Beckmeyer, T. Application of Programmed Instruction to Remedial Reading for the Deaf. <u>The Volta Review</u>, 1963, 65 (8), 415-417.

Beckmeyer, T. Receptive Abilities of Hearing Impaired Students in a Total Communication Setting. <u>American Annals of the Deaf</u>, 1976, 121 (6), 569-572.

Beech, R.P., McClelland, S.D., Horowitz, G.R., and Forlano, G. <u>Final Report: An Evaluation of the Dial A Drill Program</u>. New York State Education Department, 1970.

Behrens, T.R., Clack, L., and Alprin, L. Mathematics Curriculum Supported by Computer Assisted Instruction. American Annals of the Deaf, 1969, 114 (5), 889-892.

Bender, M.L. A Voluntary Prekindergarten Language Development and Reading Program for the Entire Four-Year-Old Population of a City (An Investigation of Machine-Taught Reading). Final Report. ERIC Document 020 855, 1968.

Berthold, H.C. and Sachs, R. Education of the Minimally Brain Damaged Child by Computer and by Teacher. Journal of Aplet, 1974, 11 (3), 121-124.

Birch, J.W. and Stuckless, E.R. Programming Instruction in Written Language for Deaf Children. American Annals of the Deaf, 1963, 108 (3), 317-336.

Birch, J.W. and Stuckless, E.R. Programmed Instruction and the Correction of Written Language of Adolescent Deaf Students. ERIC Document 003 622, 1963.

Blackman, L.S. and Copobianco, R.J. An Evaluation of Programmed Instruction with the Mentally Retarded Utilizing Teaching Machines. American Journal of Mental Deficiency, 1965, 70, 262-269.

Blackman, L.S. and Smith, M.P. The Development and Evaluation of a Curriculum for Educable Mental Retardates Utilizing Self-Instructor Devices or Teaching Machines. ERIC Document 003 176, 1964.

Bornstein, H. An Evaluation of High School Mathematics Programmed Texts When Used With Deaf Students. ERIC Document 003 292, 1964.

Brasel, K.E. and Quigley, S.P. The Influence of Early Language and Communication Environments on the Development of Language in Deaf Children. Institute for Research on Exceptional Children, University of Illinois, Urbana, 1975.

Brill, R.G. Hereditary Aspects of Deafness. The Volta Review, 1961, 63 (4), 168-175.

Brill, R.G. The Role of Communication in Psycho-Social Development. Manitoba Echo, Winnipeg; Manitoba School for the Deaf, February 1969, 8-11.

Brill, R.G. The Education of the Deaf: Administrative and Professional Developments. Washington, D.C.: Gallaudet College Press, 1974.

Brown, J. and Arkebauer, H.J. Using the Language Master With Hearing Impaired Students. Teaching Exceptional Children, 1970, 2 (2), 81-85.

Buros, O.K. The Sixth Mental Measurements Yearbook. Highland Park: The Gryphon Press, 1965, 109-128.

Buros, O.K. The Seventh Mental Measurements Yearbook. Vol. I. Highland Park: The Gryphon Press, 1972, 921-922.

Butman, C.R. C.A.L.--There Is a Way to Make It Pay (But Not in Conventional Schooling). Educational Technology, 1973, 13 (2), 5-9.

Calvert, D.R. Report on Rubella and Handicapped Children. Washington, D.C.: Project Centres Branch, Division of Educational Services, Bureau of Education for the Handicapped, HEW, May 1969.

Chomsky, C. The Acquisition of Syntax in Children From 5 to 10. Cambridge: MIT Press, 1969.

Chomsky, N. Aspects of the Theory of Syntax. Cambridge: MIT Press, 1965.

Cline, C.J. Teaching Deaf Children to Read and Write Through Programmed Instruction. The Teacher of the Deaf, 1974, 72 (424), 91-98.

Cogen, V. The Computer's Role in Education and Use With the Exceptional Child. Mental Retardation, 1969, 7 (4), 38-41.

Collins, J.F. and Calevro, M.J. Mainstreaming Special Education Using a Peer Tutoring System and a Minimum Objective Curriculum for Nine Eighth Grade Students. ERIC Document 102 788, 1974.

Coss, J.G., Forney, R.L., Wendland, L.V., and Pederson, E. Effectiveness of Automated Visual Programmed Instruction with Paraplegic and Other Severely Handicapped Students. ERIC Document 010 839, 1966.

Crawford, A.N. A Pilot Study of Computer Assisted Drill and Practice in Seventh Grade Remedial Mathematics. California Journal of Educational Research, 1970, 21 (4), 170-181.

Davis, H. and Silverman, S.R. Hearing and Deafness. 3rd ed. Toronto: Holt, Rinehart and Winston, 1970.

Deterline, W.A. An Introduction To Programmed Instruction. Englewood Cliffs: Prentice-Hall, Inc., 1962.

Devine, F.S. An Attempt to Increase Specific Reading Vocabulary by Means of Programmed Instruction Among Children with Impairment of Hearing. Dissertation Abstracts International, 1971, 31 (8-1), 3950-51, as cited in Cline, C.J. Teaching Deaf Children To Read and Write Through Programmed Instruction. The Teacher of the Deaf, 1974, 72 (424), 91-98.

Dezelle, W. The Credibility of Programmed Material as an Instructional Technique with Mentally Retarded Pupils. Education and Training of the Mentally Retarded, 1971, 6 (1), 16-19.

DiFrancesca, S. Academic Achievement Test Results of a National Testing Program for Hearing Impaired Students, United States: Spring 1971. Technical Report D-9. Washington, D.C.: Office of Demographic Studies, Gallaudet College, August 1972.

DiFrancesca, S. and Carey, S.E. Item Analysis of an Achievement Testing Program for Hearing Impaired Students, United States: Spring 1971. Technical Report D-8. Washington, D.C.: Office of Demographic Studies, Gallaudet College, March 1972.

Doehring, D.G. Picture Sound Association in Deaf Children. Journal of Speech and Hearing Research, 1968, 11 (1), 49-62.

Edwards, J., Norton, S., Taylor, S., Weiss, M. and Dusseldorp, R. How Effective is C.A.L.? A Review of the Research. Research In Review, November, 1975.

Elfner, E. Reading Curriculum Development. Project Final Report. ERIC Document 081 152, 1973.

Ellson, D.G., Harris, P., and Barber, L. A Field Test of Programmed and Directed Tutoring. Reading Research Quarterly, Spring 1968, 3 (3), 307-367.

Falconer, G.A. A Mechanical Device for Teaching Sight Vocabulary to Young Deaf Children. American Annals of the Deaf, 1961, 106 (2), 251-257.

Falconer, G.A. Teaching Machines for Teaching Reading. The Volta Review, 1962, 64 (7), 389-392.

Fant, L.J. Enough of Imitations. Deaf American, 1971, 23 (5).

Fant, L.J. ASL and English: The Various Forms of Sign Language. Deafness in Infancy and Early Childhood. Edited by P.J. Fine. New York: Medcom Press, 1974.

Fehr, J.D. Programing Language for Deaf Children. The Volta Review, 1962, 64 (1), 14-21.

Ferguson, G.A. Statistical Analysis In Psychology and Education. 3rd ed. Toronto: McGraw-Hill, Inc., 1971, 270-271.

Fessant, J.M. Application of Programmed Learning for Deaf Children to Industrial Arts. American Annals of the Deaf, 1963, 108 (2), 241-245.

Fiorentino, O.P.L. Computer Assisted Learning for Pupils With Learning Disorders. Unpublished Master's Thesis, University of Manitoba, 1977.

Fletcher, J.D. and Atkinson, R.C. Evaluation of the Stanford C.A.I. Program In Initial Reading. Journal of Educational Psychology, 1972, 63 (6), 597-602.

Fletcher, J.D. and Beard, M.H. Computer Assisted Instruction in Language Arts for Hearing Impaired Students. ERIC Document 095 857, 1975.

Fletcher, J.D. and Suppes, P. Computer Assisted Instruction in Reading: Grades 4-6. Educational Technology, 1972, 12 (8), 45-49.

Fletcher, J.D. and Suppes, P. Computer Assisted Instruction in Mathematics and Language Arts for the Deaf. Final Report. ERIC Document 084 871, 1973.

Fletcher, J.D. and Suppes, P. The Stanford Project on Computer-Assisted Instruction For Hearing-Impaired Students. Journal of Computer-Based Instruction, 1976, 3 (1), 1-12.

Fletcher, J.D., Suppes, P., and Jamison, D.T. A Note on the Effectiveness of Computer-Assisted Instruction. ERIC Document 071 450, 1972.

Fricke, J.E. C.A.I. in a School for the Deaf: Expeded Results and a Serendipity or Two. ERIC Document 129 270, 1976.

Fricklas, R. and Rusch, R. Trimodal Reading Instruction with Inefficient Learners. The Slow Learning Child, 1974, 2 (1), 44-52.

Fry, E. Programmed Instruction and Automation in Beginning Reading. ERIC Document 012 680, 1967.

Furth, H.G. Deafness and Learning: A Psychsocial Approach. Belmont: Wadsworth Publishing, Inc., 1973.

Fusfeld, I.S. How A Deaf Child Thinks. A Handbook of Readings in Education of the Deaf and Postschool Implications. Springfield: Charles C. Thomas, 1967.

Gentile, A., and Rambin, J.B. Reported Causes of Hearing Loss For Hearing Impaired Students: United States, 1970-71. Technical Report D-12. Washington, D.C.: Office of Demographic Studies, Gallaudet College, May 1973.

Gentile, A., and McCarthy, B. Additional Handicapping Conditions Among Hearing Impaired Students, United States: 1971-72. Technical Report D-14. Washington, D.C.: Office of Demographic Studies, Gallaudet College, November 1973.

Gipson, J. Use of Computer Assisted Instruction in Mathematics for Disadvantaged Seventh Grade Youth. ERIC Document 049 057, 1971.

Gipson, J. Use of Computer Assisted Instruction for Teaching Mathematics to the Disadvantaged. ERIC Document 049 057, 1971.

Green, E.J. The Learning Process and Programmed Instruction. New York: Holt, Rinehart and Winston, Inc., 1962.

Green, D.R. Learning to Recognize Words and Letters on a C.A.I. Terminal. ERIC Document 027 177, 1968.

Grigonis, D.F. Development and Evaluation of Programmed Instruction in the Teaching of Verbs to Deaf Children in the Primary Grades. Final Report. ERIC Document 056 424, 1970.

Hankin, E.K., Smith, E.H., and Smith, T.A. The Development of Pre-Vocational Education Literacy Courses for use with Computer Assisted Instruction of Disadvantaged Youths and Adults. Final Report. ERIC Document 024 763, 1967.

Hartley, J. Research Report. New Education, 1966, 2, 29-35.

Haskell, S.H. Impairment of Arithmetic Skills in Cerebral Palsied Children and a Programmed Remedial Approach. ERIC Document Abstract 11029, 1967.

Higgins, C. and Rusch, R.R. Development and Evaluation of Auto-Instructional Programs in Arithmetic for the Educable Mentally Handicapped. Final Report. ERIC Document 014 190, 1967.

Hill, K.A. Computer Assisted Learning with the Physically Handicapped. Unpublished Master's Thesis, University of Manitoba, 1976.

Jamison, D., Suppes, P., and Wells, S. The Effectiveness of Alternative Instructional Media: A Survey. Review of Educational Research, 1974, 44 (1), 1-67.

Jensema, C. Post Rubella Children in Special Educational Programs for the Hearing Impaired. The Volta Review, 1974, 76 (8), 466-473.

Jensema, C. and Mullins, J. Onset, Cause, and Additional Handicaps in Hearing Impaired Children. American Annals of the Deaf, 1974, 119 (6), 701-705.

Jensema, C. The Relationship Between Academic Achievement and Demographic Characteristics of Hearing Impaired Children and Youth. Technical Report R-2. Washington, D.C.: Office of Demographic Studies, Gallaudet College, September 1975.

Johnson, G.F. An Investigation of Programmed Procedures in Teaching Addition and Subtraction to Educable Mentally Retarded Subjects. Unpublished Doctoral Dissertation, University of Oregon, 1966.

Johnson, K.A. A Survery of Mathematics Programs, Materials and Methods in Schools for the Deaf. American Annals of the Deaf, 1977, 122 (1), 19-25.

Johnson, M.S., and Kress, R.A. Informal Reading Inventories. Newark: International Reading Association, 1975, 5-7.

Jordan, I.K., Gustason, G., and Rosen, R. Current Communication Trends at Programs for the Deaf. American Annals of the Deaf, 1976, 121 (6), 527-532.

Kaplan, J.D. An Example of a Mathematics Instructional Program for Disadvantaged Children. Educational Technology, 1969, 9 (8), 40-43.

Karlsen, B. A Research Basis for Reading Instruction of Deaf Children. American Annals of the Deaf, 1965, 110 (5), 535-540.

Karlsen, B. Teaching Beginning Reading to Hearing Impaired Children, Using a Visual Method and Teaching Machines. Final Report. ERIC Document 015 603, 1966.

Kearsley, G.P., Squires, D., and King, B. A C.A.I. Program to Teach Deaf Children How to Use a Ruler: A Study in Instructional Design. RIR-77-8, Division of Educational Research, University of Alberta, 1977.

Kennedy, A.E.C. The Miniature Linguistic System As A Code-Breaking Device for the Deaf. Unpublished Doctoral Thesis, University of Minnesota, 1972.

Knutson, J. and Prochnow, R.R. Computer Assisted Instruction for Vocational Rehabilitation of the Mentally Retarded. ERIC Document 044 039, 1970.

Krumboltz, J.D. Needed Research in Programmed Instruction. _Educational Leadership_, 1963, 21, 30-33, as cited in Lumsden, D.B. Individualizing Instruction Through the Use of Programmed Instruction. _The Educational Forum_, 1974, 38 (2), 145-152.

Lance, W.D. Technology and Media for Exceptional Learners: Looking Ahead. _Exceptional Children_, 1977, 44 (2), 92-97.

Lange, P.C. Programmed Learning. _Today's Education_. The Journal of the National Education Association, 1972, 61(2), 59.

Lennan, R.K. Use of Programmed Instruction with Emotionally Disturbed Deaf Boys. _American Annals of the Deaf_, 1969, 114 (5), 906-911.

Lenneberg, E.H. _Biological Foundations of Language_. New York: J. Wiley and Sons, Inc., 1967.

Leonard, J.M. Computer Assisted Instruction for the Handicapped, 1970, as cited in The Role of Media in the Education of Emotionally Handicapped Children, ERIC Document 046 158, 1970.

Ling, D. _Speech and the Hearing-Impaired Child: Theory and Practice._ Washington D.C.: The Alexander Graham Bell Association for the Deaf, Inc., 1976.

Litman, G.H. C.A.I. in Chicago. ERIC Document 087 423, 1973.

Littrell, R.F. The Economics of Computer Aided Instruction. ERIC Document 087 418, 1973.

Loban, W. _The Language of Elementary School Children_. Champaign: National Council of Teachers of English, 1963.

Madachy, J.L., and Miller, J.D. The Use of C.A.I. in the Language Program at Gallaudet. ERIC Document 119 625, 1976.

Majer, K. Computer Assisted Instruction and Reading. Viewpoints, 1972, 48 (5), 77-98.

Majer, K. Computer Assisted Instruction and Reading: How, What, When and Where? Educational Technology, 1973, 13 (9), 23-27.

Malpass, L.F. Comparison of Two Automated Teaching Procedures for Retarded Children. ERIC Document 003 063, 1963.

Malpass, L.F. Programmed Reading Instruction for Culturally Deprived Slow Learners. ERIC Document 011 065, 1966.

Malpass, L.F., Williams, C.F., and Gilmore, A.S. Further Developments, Comparison and Evaluation of Programmed Instruction for Retarded Children. Final Report. ERIC Document 025 052, 1967.

Martin, J.H. Freeport Public Schools Experiment on Early Reading Using the Edison Responsive Environment Instrument. ERIC Document 002 586, 1964.

McConnel, F. Children with Hearing Disabilities. Exceptional Children in the Schools. Edited by L.M. Dunn. 2nd ed. Toronto: Holt, Rinehart and Winston, Inc., 1973.

McDearmon, J.R. A Method of Teaching Lipreading Using Programmed Learning Principles. The Volta Review, 1967, 69 (5), 316-318.

McGrady, H.J. The Influence of a Program of Instruction Upon the Conceptual Thinking of the Deaf. The Volta Review, 1964, 66 (7), 531-536.

McKinney, V. The Illiterate Deaf Adult--An Investigation in Communication Skills, 1972, as cited in Spidal, D.A. and Pfau, G.S. The Potential for Language Acquisition of Illiterate Deaf Adolescents and Adults. Journal of Rehabilitation of the Deaf, 1972, 6 (1), 27-41.

McNeil, D. The Capacity for Language Acquisition. The Volta Review, 1966, 68 (1), 17-33.

Metzger, R. Aspects of Arithmetic Learning in Mental Retardation. ERIC Document Abstract 23343, 1966.

Miller, J. Practices in Language Instruction. Exceptional Children, April 1964, 30 (8), 355-357.

Miller, J.B. Oralism. The Volta Review, 1970, 72 (4), 211-217.

Mindel, E.D. and Vernon, M. They Grow In Silence. Silver Spring: National Association of the Deaf, 1971.

Moores, D.F. and Quigley, S.R. Cloze Procedures in Assessment of Language Skills of Deaf Persons. Proceedings of the International Conference on Oral Education of the Deaf, Vol. II. Washington, D.C.: The Alexander Graham Bell Association for the Deaf, Inc., 1967, 1363-1382.

Moores, D.F. Psycholinguistics and Deafness. American Annals of the Deaf, 1970, 115 (1), 37-48.

Moores, D.F., Weiss, K.L., and Goodwin, M.W. Evaluation of Programs For Hearing Impaired Children: Report of 1973-74. Research Report #81. University of Minnesota: Research, Development and Demonstration Center in Education of Handicapped Children, University of Minnesota, December 1974.

Morgan, J.M. Computer-Assisted Instruction for the Blind and Deaf. ERIC Document 107 039, 1975.

Myklebust, H.R. The Psychology of Deafness. 2nd ed. New York: Grune and Stratton, 1964.

Naumann, T.F., Porter, L.A., and Wensley, O.W. Principles of Learning Applied in Automated Instruction of Handicapped Pupils. Cited by L. Malpass, Programmed Instruction for Retarded Children. In A.A. Baumeister (Ed.), Mental Retardation. Chicago: Adeline Publishing Company, 1967.

Nelon, E.M. An Evaluation of Computer-Assisted Vocabulary Instruction with Mentally Retarded Children. ERIC Document 090 964, 1972.

Newby, H.A. Audiology. 3rd ed. New York: Appleton-Century-Crofts, 1972.

Newcomb, W.B. Computer Aided Language Training. Proceedings of the Forty-Eighth Meeting of the Conference of Executives of American Schools for the Deaf, Inc., Fulton: Missouri School for the Deaf, 1976.

Neyhus, A.I. Self Teaching in the Development of Speechreading in Deaf Children. ERIC Document 012 992, 1967.

Nomeland, R.E. and Harris, R. Computer-Assisted Instruction at Kendall Demonstration Elementary School. ERIC Document 129 273, 1976.

Parsons, B. Developing Basic Cursive Writing Skills. Cited by L. Malpass, Programmed Instruction for Retarded Children. In A.A. Baumeister (Ed.), Mental Retardation. Chicago: Adeline Publishing Company, 1967.

Pfau, G.S. Programed Instruction: An Exploration into its Effectiveness with the Handicapped Child. Audiovisual Instruction, 1969, 14 (9), 24-27.

Pfau, G.S. Project LIFE PI Analysis. American Annals of the Deaf, 1969, 114 (5), 829-837.

Pfau, G.S. Project LIFE: Developing High Interest Programmed Materials for Handicapped Children. Educational Technology, 1970, 10 (8), 13-18.

Pfau, G.S. The Application of Programmed Instruction Principles to Classroom Instruction. The Volta Review, 1970, 72 (6), 340-348.

Piecewicz, R.E. Computers and Society: Some Principles, Theorems, and Assertions. Computers and People, 1977, 26 (4), 13-16.

Pressey, S.L. Paper Delivered at Project LIFE Programming Conference, Ohio State University, September 20, 1967.

Price, J.E. A Comparison of Automated Teaching Programs with Conventional Teaching Methods as Applied to Teaching Mentally Retarded Students. ERIC Document 003 654, 1961.

Prince, J.D. A Practitioner's Report: Results of Two Years of Computer Assisted Instruction in Drill and Practice in Mathematics for the Period June 15, 1967 to May 30, 1969. Progress Report No. 3. ERIC Document 032 769, 1969.

Proceedings of the Forty-Seventh Meeting of the Conference of Executives of American Schools for the Deaf, Inc., Fulton: Missouri School for the Deaf, 1975.

Rainey, D.S. An Unpublished Study, 1965, as cited in Rainey, D.S. and Kelly, F.J. An Evaluation of a Programed Textbook with Educable Mentally Retarded Children. Exceptional Children, 1967, 34 (3), 169-174.

Rainey, D.S. and Kelly, F.J. An Evaluation of a Programmed Textbook with Educable Mentally Retarded Children. Exceptional Children, 1967, 34 (3), 169-174.

Rawlings, B. Characteristics of Hearing Impaired Students By Hearing Status, United States: 1970-71. Technical Report D-10. Washington, D.C.: Office of Demographic Studies, Gallaudet College, March 1973.

Richardson, E. and Collier, E. Programmed Tutoring of Decoding Skills with Third and Fifth Grade Non-Readers. The Journal of Experimental Education, 1971, 39 (3), 57-64.

Roy, H.L., Schein, J.D., and Frisina, R.D. New Methods of Language Development for Deaf Children. ERIC Document 001 195, 1964.

Rudisill, V.A. and Jabs, M.L. Multimedia Instruction in Basic English. ERIC Document 128 056, 1976.

Rush, M.L. Programmed Instruction for "The Language of Directions". American Annals of the Deaf, 1964, 109 (4), 356-358.

Rush, M.L. Use of Visual Memory in Teaching Written Language Skills to Deaf Children. Journal of Speech and Hearing Disorders, 1966, 31 (3), 219-226.

Rush, M.L. The Language of Directions--A Programmed Workbook. Washington, D.C.: The Alexander Graham Bell Association for the Deaf, Inc., 1972.

Russell, W.K., Quigley, S.P., and Power, D.J. Linguistics and Deaf Children. Washington, D.C.: The Alexander Graham Bell Association for the Deaf, Inc., 1976.

St. Aubin, R. Evaluation of C.A.I. as Used by Various Handicaps. ERIC Document 136 775, 1975.

Salisbury, A.B. Overview of C.A.I. Educational Technology, 1971, 11(10), 48-50.

Sandals, L.H. Computer Assisted Learning with the Developmentally Handicapped. Unpublished Doctoral Thesis, University of Calgary, 1973.

Sanders, D.A. Aural Rehabilitation. Englewood Cliffs: Prentice-Hall, Inc., 1971.

Scherer, P. Visual Learning Processes in Deaf Children. Proceedings of International Conference on Oral Education of the Deaf, Vol. II. Washington, D.C.: The Alexander Grahm Bell Association for the Deaf, Inc., 1967, 1997-2011.

Schiavone, J., Rowen, D., and Farrell, M.L. Computer Assisted Instruction in Reading. Education, 1971, 91 (4), 301-302.

Schramm, W. The Research on Programmed Instruction: An Annotated Bibliography. Washington, D.C.: U.S. Department of Health, Education and Welfare, 1964.

Simmons-Martin, A. The Oral/Aural Procedure: Theoretical Basis and Rationale. The Volta Review, 1972, 74 (9), 541-51.

Smetana, M. and Others. A Pilot Study of the Oralographic Reading Program. Exceptional Child Education Abstracts 1564, Spring 1975, 7 (1), 266.

Smith, E.B., Goodman, K.S., and Meredith, R. Language and Thinking In The Elementary School. Toronto: Holt, Rinehart, and Winston, Inc., 1970.

Smith, J.M. and vonFeldt, J.R. A Comparison of Two Media: An Examination of Computer Assisted and Videotaped Instruction in Teaching Diacritical Markings to Post Secondary Deaf Students. An Unpublished Manuscript, Rochester: National Technical Institute For The Deaf, 1977.

Snyder, S. Introduction. American Annals of the Deaf, 1971, 116 (5), 446-448.

Spidal, D.A., and Pfau, G.S. The Potential For Language Acquisition of Illiterate Deaf Adolescents and Adults. Journal of Rehabilitation of the Deaf, July 1972, 6 (1), 27-41.

Steg, D. Effects of Individualized Programmed Instruction of Initial Reading Skills and Language Behavior in Early Childhood. ERIC Document 028 026, 1968.

Stepp, R.E. A Speechreading Laboratory for Deaf Children. The Volta Review, 1971, 68 (6), 408-415.

Steppe, R.E. Foreward. American Annals of the Deaf, 1971, 116 (5), 443-444.

Stokoe, W.C. Sign Language Structure: An Outline of the Visual Communication Systems of the American Deaf. Occassional Paper #8. Buffalo: University of Buffalo Studies in Linguistics, 1960.

Stolurow, L.M. Automation in Special Education. Exceptional Children. 1960, 27 (2), 78-83.

Stovall, G.P. A Comparatice Study of C.A.L. in Arithmetic Computation in the Public Schools of McComb, Mississippi. Unpublished Doctoral Thesis, 1969, as cited in Gipson, J. Use of Computer Assisted Instruction for Teaching Mathematics to the Disadvantaged. ERIC Document 051 672, 1971.

Street, W.P. Computerized Instruction in Mathematics Versus Other Methods of Mathematics Instruction Under ESEA Title I Programs in Kentucky. ERIC Document 068 354, 1972.

Stuckless, E.R. and Birch, J.W. A Programmed Approach to Written Language Development in Deaf Children. The Volta Review, 1962, 64 (7), 415-417.

Stuckless, E.R. and Birch, J.W. Programmed Instruction in Written Language for the Deaf. Exceptional Children, 1964, 30 (7), 296-303.

Stuckless, E.R. Programmed Instruction and Errors in the Written Language of Deaf Adolescents. Unpublished Doctoral Dissertation, University of Pittsburgh, 1963, as cited in Rosenstein, J., The Deaf and Hard of Hearing. Review of Educational Research, 1966, 36 (1), 190-191.

Suppes, P. Computer Assisted Instruction in the Schools: Potentialities, Problems, Prospects. ERIC Document 021 482, 1965.

Suppes, P. A Survey of Cognition in Handicapped Children. Review of Educational Research, 1974, 44 (2), 145-176.

Suppes, P. and Fletcher, J.D. Computer Assisted Instruction in Mathematics and Language Arts for Deaf Students. ERIC Document 093 365, 1974.

Suppes, P., Fletcher, J.D., and Zanotti, M. Models of Individual Trajectories in Computer-Assisted Instruction for Deaf Students. Journal of Educational Psychology, 1976, 68 (2), 117-127.

Suppes, P., Fletcher, J.D., Zanotti, M., Lorton, P.V., and Searle, B.W. Evaluation of Computer Assisted Instruction in Elementary Mathematics for Hearing Impaired Students. ERIC Document 084 722, 1973.

Taylor, S., Edwards, J., Norton, S., Van Dusseldorp, R., and Weiss, M. The Effectiveness of C.A.I. ERIC Document 092 074, 1974.

Thibodeau, G.P. and Vitello, S.J. The Use of Programmed Instruction in Developing the Computational Skills of Mentally Retarded Children. Mental Retardation, 1974, 12 (4), 46-48.

Thompson, H. An Early Attempt in Profusely Illustrated Language Instruction. Exceptional Children, 1964, 30 (8), 349-353.

Torr, D.V. Gallaudet College Update. ERIC Document 119 624, 1976.

Trybus, R.J. Paper presented at Western Maryland College, July 1975, Westminister, Maryland.

Trybus, R.J. and Karchmer, M.A. School Achievement Scores of Hearing Impaired Children: National Data on Achievement Status and Growth Patterns. American Annals of the Deaf, 1977, 122 (2), 62-68.

Tulane University of Louisiana, New Orleans. Head Start Evaluation and Research Center, Annual Report. ERIC Document 029 705, 1968.

van Uden, A. New Realizations In The Light of the Pure Oral Method. The Volta Review, 1970, 72 (9), 524-536.

Vergason, G.A. Retention in Educable Retarded Subjects for Two Methods of Instruction. American Journal of Mental Deficiency, 1966, 71, 633-688.

Vernon, M. Fifty Years of Research on the Intelligence of Deaf and Hard of Hearing Children: A Review of Literature and Discussion of Implications. Journal of Rehabilitation of the Deaf, 1968, 1, 1-12.

Vernon, M. Multiply Handicapped Deaf Children: Medical, Educational, and Psychological Considerations. Washington, D.C.: The Council for Exceptional Children, 1969.

Vernon, M., and Koh, S.D. Early Manual Communication and Deaf Children's Achievement. American Annals of the Deaf, 1970, 115 (5), 527-536.

Vernon, M., and Koh, S.D. Effects of Oral Preschool Compared to Early Manual Communication on Education and Communication in Deaf Children. American Annals of the Deaf, 1971, 116 (6), 569-574.

Vockell, K. and Vockell, E.L. Language for Mentally Retarded Deaf Children: Project LIFE. The Volta Review, 1973, 75 (7), 431-439.

vonFeldt, J.R. An Overview of Computers in Education. An Unpublished Manuscript, Rochester: National Technical Institute For The Deaf, March, 1977.

vonFeldt, J.R. An Introduction to Computer Applications in Support of Education. An Unpublished Manuscript, Rochester: National Technical Institute for the Deaf, August, 1977.

Washington University, Seattle, Child Development and Health Retardation Center. Investigation of Systematic Instructional Procedures to Facilitate Academic Achievement in Mentally Retarded Disadvantaged Children. Final Report. ERIC Document 071 248, 1971.

Warner, D. Experimental Phonetic Reading Program for Exceptional Pupils. ERIC Document 015 848, 1967.

Weyer, S.A. Fingerspelling by Computer. Technical Report No. 212. ERIC Document 084 723, 1973.

White, A.H. and Stevenson, V.M. The Effects of Total Communication, Manual Communication, Oral Communication and Reading on the Learning of Factual Information in Residential School Deaf Children. American Annals of the Deaf, 1975, 120 (1), 48-57.

Winer, B.J. Statistical Principles in Experimental Design. Toronto: McGraw-Hill, Inc., 1962.

Withrow, F. Priority Recommendations of the National Advisory Committee on Education of the Deaf. Report of the Proceedings of the Forty-Sixth Meeting of the Convention of American Instructors of the Deaf. Washington, D.C.: U.S. Government Printing Office, 1974, 405-414.

Woodcock, R.W. The Peabody-Chicago-Detroit Reading Project--A Report of the Second-Year Results. ERIC Document 017 413, 1967.

Woolman, M. and Davy, R.A. Developing Symbolic Skills in the Mentally Retarded. Washington, D.C.: Institute of Educational Research, 1963.

Zoll, E.J. Research in Programmed Instruction in Mathematics. The Mathematics Teacher, 1969, 62 (2), 103-110.

APPENDICES

APPENDICES A AND B

READING COMPREHENSION AND MATHEMATICS COMPUTATION SCORES

APPENDIX A

Figure 1: Reading Comprehension Scores National Distribution for Hearing Impaired Students

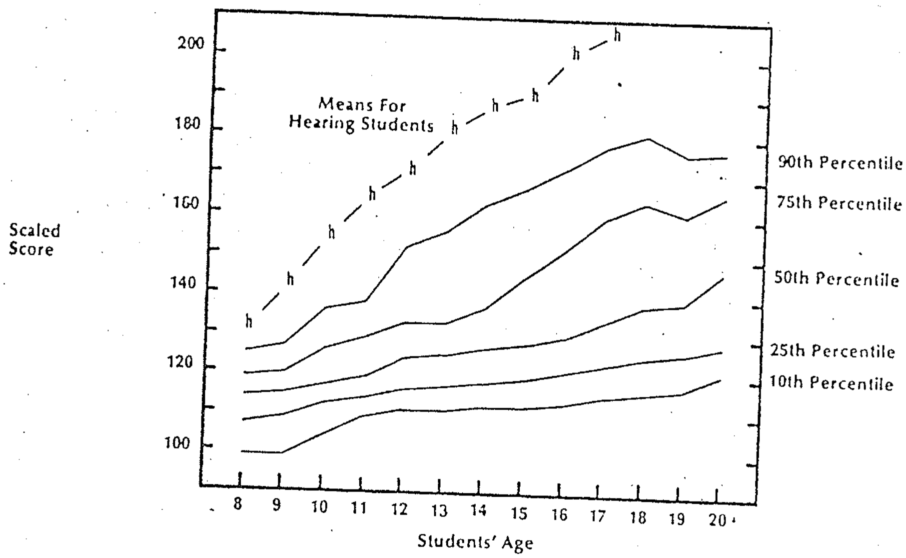
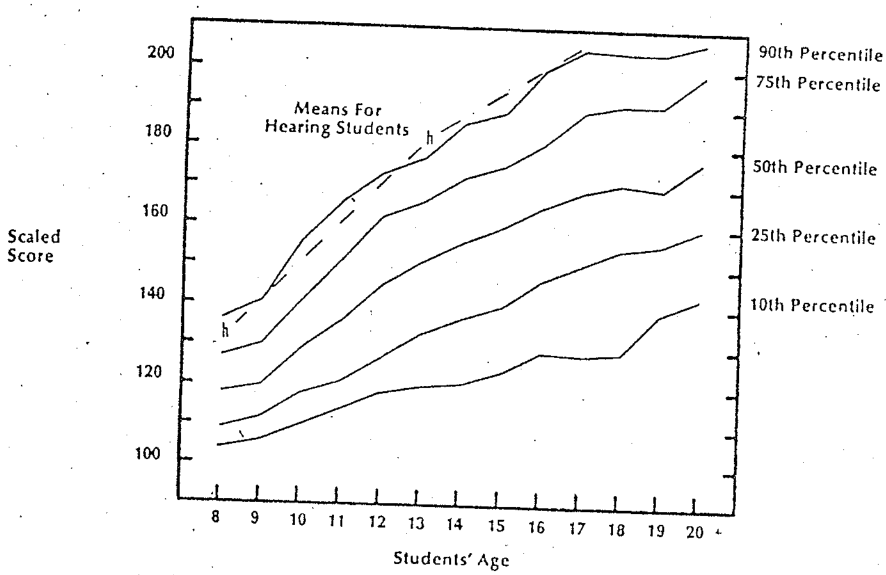


Figure 2: Mathematics Computation Scores National Distribution for Hearing Impaired Students



Source: Trybus and Karchmer (1977)

APPENDIX B

MEAN GRADE LEVEL OF STUDENTS WITH 60 dB (ISO) OR GREATER HEARING LOSS

Academic Achievement Test Performance of Hearing Impaired Students

U.S: Spring 1969

Office of Demographic Studies, Gallaudet College, Washington, D.C.

Reading

Age	8	9	10	11	12	13	14	15	16	17	18	19
Test Battery												
Primary I	1.87	1.91	1.97	2.04								
Primary II			2.38	2.50	2.41	2.51	2.44					
Intermediate I					3.41	3.46	3.33	3.33	3.35			
Intermediate II						3.97	4.31	4.24	4.17	4.02		

Language

	8	9	10	11	12	13	14	15	16	17	18	19
Primary II			2.98	3.17	2.99	3.04	2.87					
Intermediate I					3.42	3.54	3.41	3.40	3.48			
Intermediate II						4.13	4.66	4.50	4.57	4.40		
Advanced								5.46	5.82	6.02	6.15	6.00

Arithmetic Computation

	8	9	10	11	12	13	14	15	16	17	18	19
Primary II			2.93	3.59	3.44	3.72	3.83					
Intermediate I					4.43	4.78	4.76	5.30	5.25			
Intermediate II						4.85	5.74	5.94	6.20	6.05		
Advanced								6.50	7.27	7.63	7.94	7.84

Source: Adapted from Spidal and Pfau (1972).

APPENDIX C

SUMMARY PROFILES OF SUBJECTS

APPENDIX C

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 1

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
1	M	10.00	D	102	2.15	None	NA
2	F	8.11	D	80	2.25	None	Superior (1972)
3	M	10.10	R	101	2.10	None	Mid Average (1971)
4	M	11.02	D	106	2.50	Rubella Cataracts	Dull Normal (1970)
5	F	10.03	R	100	2.30	None	Low Average (1971)
6	F	10.07	R	103	2.15	None	Dull Normal to Low Average (1971)
7	M	10.04	R	73	1.95	None	Mid Average (1971)
8	F	12.04	D	95	1.75	None	Borderline to Low Dull Normal (1969)

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 1

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
9	F	11.06	D	110	2.00	None	High Dull Normal to Low Average (1973)
10	M	11.02	D	103	1.65	None	Mid Average (1969)
11	M	11.03	D	91	1.75	None	Mid Average (1969)
12	M	11.01	D	83	1.45	None	Mid Average (1973)
13	M	11.11	R	73	2.40	None	NA
14	M	15.06	D	110	2.15	None	Dull Normal (1966)
15	F	13.03	R	110	1.75	None	Normal (1968)
16	M	13.07	R	107	1.95	None	Average (1972)

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 1

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
17	F	13.01	R	96	2.00	None	Dull Normal (1968)
18	M	16.11	D	90	7.50	None	Bright Normal to Superior (1970)
19	F	17.07	D	93	4.80	None	Mid-Dull Normal (1970)
20	M	15.03	D	102	4.40	None	NA
21	F	16.04	D	105	3.45	None	Very Superior (1974)
22	F	16.04	D	61*	6.50	None	NA
23	M	16.08	R	71	3.00	None	NA
24	M	15.10	R	95	3.15	None	NA
25	M	15.06	R	101	2.95	None	Bright Normal (1969)

* Moderate

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 2

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
1	M	8.10	D	102	NA	None	Average (1971)
2	M	9.05	D	105	NA	None	Bright Normal (1973)
3	M	8.05	D	103	NA	None	Low to Mid-Average (1973)
4	F	8.10	R	105	2.30	None	Tentative Borderline to Dull Normal (1973)
5	M	8.11	R	90	NA	None	High Borderline (1972)
6	F	8.06	R	108	NA	None	Mid Average (1972)
7	M	9.09	R	83	1.70	None	Borderline (1972)
8	F	9.09	R	110	1.25	None	Borderline (1972)

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 2

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
9	F	9.04	D	103	1.55	None	Dull Normal to Low Average (1972)
10	M	10.06	D	95	1.35	None	Average (1973)
11	M	9.05	R	90	1.45	None	Mildly Retarded to Borderline (1972)
12	M	9.11	D	95	1.65	None	Low Average (1972)
13	F	12.02	D	102	1.65	None	Tentative Mildly Retarded (1973)
14	M	12.00	D	90	2.00	Cataracts Rubella	Dull Normal (1969)
15	M	11.02	R	97	1.75	None	Mid to Above Average (1973)
16	M	11.08	D	85	2.10	Perceptual Problems	Borderline (1972)

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 2

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
17	F	11.00	D	103	2.55	Cerebral Palsy Rubella	Mid-Dull Normal (1970)
18	F	11.05	R	105	2.50	None	Mid-Average (1975)
19	F	10.11	D	100	2.40	None	High Average to Bright Normal (1969)
20	M	11.01	R	98	1.75	None	NA
21	M	11.02	D	106	2.20	None	Bright Normal (1970)
22	F	12.09	D	101	1.75	None	NA
23	F	12.01	R	86	1.85	None	NA
24	M	11.05	D	110	2.15	None	Low Average (1969)
25	M	11.03	D	100	2.20	None	NA

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 2

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
26	F	18.07	R	100	3.10	None	NA
27	M	16.10	D	80	3.25	None	Normal (1965)
28	F	16.07	D	102	3.25	None	Superior (1974)
29	F	17.08	D	110	3.45	None	NA

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 3

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
1	F	9.01	D	95	NA	None	Borderline (1972)
2	F	8.01	D	98	NA	None	Tentative Borderline to Low Dull Normal (1973)
3	F	9.01	D	107	NA	None	NA
4	M	8.00	D	100	NA	Perceptual Problems	NA
5	M	10.08	D	88	1.95	Behavior Disorder	Dull Normal (1973)
6	M	10.04	D	108	1.90	Visual Acuity	Mid-Average (1972)
7	M	10.04	D	105	1.95	Rubella Complications	Low Average (1971)
8	M	10.03	D	100	1.80	None	Superior (1972)
9	F	10.06	D	107	1.70	Behavior Disorder	Mid-Average (1970)

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 3

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
10	F	10.04	R	76	2.15	None	Dull Normal (1974)
11	M	16.05	R	65*	3.55	Aphasic	Normal (1967)
12	F	17.11	D	91	3.40	None	High Borderline (1972)
13	M	16.07	D	110	2.45	None	Tentative High Dull Normal to Low Average (1969)
14	M	18.08	D	101	3.00	None	NA
15	M	14.02	R	107	1.80	Short Attention Span	Mid-Average (1970)
16	F	14.06	D	106	2.80	None	NA
17	M	13.00	R	97	2.55	None	Borderline (1968)

* Moderate

APPENDIX C (cont'd.)

SUMMARY PROFILES OF SUBJECTS

TREATMENT GROUP 3

Subject	Sex	Age	Day/ Resident	Hearing Loss	Average Reading Level	Multiple Handicapping Conditions	Level of Intelligence
18	F	13.01	R	103	1.70	None	Low Normal (1968)
19	M	13.09	D	106	1.75	Progressive Blindness	Mid-Average (1970)

APPENDIX D

SAMPLE COMPUTER PROGRAMS

```
/CALL,MSD(P=COUNT20)

DATE: 77/12/14.      TIME: 20.57.07.

WHAT IS YOUR STUDENT NUMBER ? MSD999

WHAT IS YOUR FIRST NAME ? LOU

WHAT IS YOUR LAST NAME  ? REEVES

TEACHER OR STUDENT TO PUT IN THE PARAMETERS
BETWEEN 1 AND 20.

DO YOU WANT FULL DATA (1) OR SHORTENED DATA (2) ? 1
HOW MANY PROBLEMS DO YOU WANT (FROM 1 TO 20)? 10
LEAST NUMBER OF ITEMS TO BE COUNTED ? 1
LARGEST NUMBER OF ITEMS TO BE COUNTED ? 12
DO YOU WANT THE COUNTING INTRODUCTION?  YES OR NO.? NO

------------------------------------------------------------

HERE ARE SOME BOXES [] AND DOLLARS $ TO BE COUNTED, LOU.

[]      []      []      []

 =  ? 4
      < LOU


$      $      $      $      $      $      $

 =  ? 7
      < LOU


[]      []      []      []

 =  ? 4
      < LOU


$      $      $      $      $      $      $

 =  ? 7
      < LOU
```

```
$    $    $    $    $    $    $    $    $    $
$

 =  ? 11
     < LOU


$    $    $    $    $    $    $    $    $    $


 =  ? 10
     < LOU


[]    []    []
 =  ? 3
     < LOU


$    $    $    $    $    $
 =  ? 6
     < LOU


[]    []
 =  ? 2
     < LOU


$    $    $    $    $    $    $    $    $    $


 =  ? 10
     < LOU

--------------------------------------------------------------------
THAT IS ALL FOR NOW LOU DO YOU HAVE TIME FOR MORE?
TYPE IN YES OR NO ? NO

THAT'S ALL, LOU. YOU HAD  10  CORRECT ANSWERS AND
 0  WRONG ANSWERS.
THAT GIVES YOU  100  PERCENT.

GOODBYE LOU REEVES COME AGAIN SOON.
```

```
DATE: 77/12/14.    TIME: 21.16.47.

WHAT IS YOUR STUDENT NUMBER ? MSD999

WHAT IS YOUR FIRST NAME ? LOU

WHAT IS YOUR LAST NAME  ? REEVES

THIS IS A SUBTRACTION PROGRAMME DESIGNED TO GIVE THE
STUDENT PRACTICE WITH PROBLEMS SPECIFIED BY THE TEACHER.

HOW MANY PROBLEMS (FROM 1 TO 20) WOULD YOU LIKE.? 10

HOW MANY DIGITS (FROM 1 TO 5) DO YOU WANT IN THE LARGER
NUMBER. ? 4

HOW MANY DIGITS (FROM 1 TO  4 ) DO YOU WANT IN THE
SMALLER NUMBER. ? 3

HI, MY NAME IS NOS, THE FRIENDLY COMPUTER.

-----------------------------------------------------------

O.K., LOU.  TRY SUBTRACTING THESE PROBLEMS.

WHEN THE MACHINE STOPS, TYPE IN THE ANSWER FOR THAT COLUMN
ONLY.  PRESS THE RETURN BUTTON AND WAIT FOR THE NEXT '?'.


     4  0  6  6
-       3  2  5
----------------
             ? 1
         ? 4
       ? 7
  ? 3

< GOOD WORK, LOU.  THE ANSWER IS 3741 .


     5  3  8  5
-       4  2  7
----------------
             ? 8
         ? 5
       ? 9
  ? 5

X THAT'S NOT RIGHT, LOU.  TRY AGAIN.
  ? 4

< GOOD WORK, LOU.  THE ANSWER IS 4958 .
```

DATE: 77/12/14. TIME: 21.42.41

WHAT IS YOUR STUDENT NUMBER ? MSD999

WHAT IS YOUR FIRST NAME ? LOU

WHAT IS YOUR LAST NAME ? REEVES

DRILL IN LANGUAGE ARTS - SENTENCE PATTERNS BASED ON
THE RHODE ISLAND LANGUAGE CURRICULUM FOR THE DEAF.

DO YOU WANT TO SEE THE LIST OF DRILLS. YES OR NO? NO

WHICH DRILL DO YOU WANT (1, 2, 3, 4 OR 5)? 1

HOW MANY QUESTIONS (FROM 1 TO 15) DO YOU WANT ? 10

DO YOU WANT TO COPY EACH SENTENCE? 'YES' OR 'NO'? NO

DRILL NUMBER 1 - WHO, WHAT.

HERE ARE THE DIRECTIONS.....

TYPE IN 'WHO' WHEN THE SENTENCE IS ABOUT A PERSON.

TYPE IN 'WHAT' WHEN THE SENTENCE IS NOT ABOUT A PERSON.

```
1 .    LARRY FELL.
            =====!       ? WHO
```

CORRECT LOU.

```
2 .    A CAT RAN.
            ====!       ? WHAT
```

RIGHT ON LOU.

```
3 .    THE WORM CRAWLED.
                =========!       ? WHAT
```

CORRECT LOU.

```
4 .    THE TEACHER WALKED.
                   =======!       ? WHO
```

YOU ARE DOING FINE.

5 . A BALLOON BURST.
======! ? WHAT

RIGHT ON LOU.

6 . A BALLOON BURST.
======! ? WHAT

YOU ARE DOING FINE.

7 . THE BUS DRIVER WAITED.
=======! ? WHO

CORRECT LOU.

8 . A BALLOON BURST.
======! ? WHAT

RIGHT ON LOU.

9 . THE RAIN FELL.
=====! ? WHAT

YOU ARE DOING FINE.

10 . LARRY FELL.
=====! ? WHO

CORRECT LOU.

THE DRILL IS OVER LOU REEVES. OUT OF 10 QUESTIONS
YOU HAD 10 RIGHT AND 0 WRONG.

YOUR SCORE IS 100 PERCENT.

DATE: 77/12/15. TIME: 16.21.44.

WHAT IS YOUR STUDENT NUMBER ? MSD999

WHAT IS YOUR FIRST NAME ? LOU

WHAT IS YOUR LAST NAME ? REEVES

THIS IS A DRILL IN POSSESSIVE FORMS OF SINGULAR AND
PLURAL NOUNS, ADJECTIVES, AND PRONOUNS.

DO YOU WANT TO SEE A LIST OF THE AVAILABLE TOPICS ? NO

WHICH TOPIC (FROM 1 TO 5) DO YOU WANT ? 1

DO YOU WANT TO SEE THE RULES FOR POSSESSIVE FORMS OF
NOUNS ? NO

HOW MANY QUESTIONS (FROM 1 TO 15) DO YOU WANT ? 8

DO YOU WANT TO SEE THE DIRECTIONS ? NO

O.K., LOU. LET'S GO...

THE EYES OF PAUL ARE BLUE.
( ) EYES ARE BLUE.
(? PAUL'S

PERFECT, LOU

THE CHEEKS OF THE SQUIRREL ARE FILLED WITH NUTS.
THE ( ) CHEEKS ARE FILLED WITH NUTS.
THE (? SQUIRREL'S

PERFECT, LOU

THE IDEA OF THE ELF WAS TO USE MUSHROOMS AS UMBRELLAS.
THE ( ) IDEA WAS TO USE MUSHROOMS AS UMBRELLAS.
THE (? ELF'S

THAT'S GREAT, LOU

APPENDIX E

DATA TREATMENT DESIGN

DATA TREATMENT DESIGN

	Subjects	Pretest (1) b1	Pretest (2) b2	Post Test b3	Retention Test b4
Treatment Group 1 C.A.L. - Language Arts	1	X_{111}	X_{112}	X_{113}	X_{114}
	2	X_{211}	X_{212}	X_{213}	X_{214}
	3	X_{311}	X_{312}	X_{313}	X_{314}
	⋮	⋮	⋮	⋮	⋮
	n	X_{n11}	X_{n12}	X_{n13}	X_{n14}
Treatment Group 2 C.A.L. - Combined Group	1	X_{121}	X_{122}	X_{123}	X_{124}
	2	X_{221}	X_{222}	X_{223}	X_{224}
	3	X_{321}	X_{322}	X_{323}	X_{324}
	⋮	⋮	⋮	⋮	⋮
	n	X_{n21}	X_{n22}	X_{n23}	X_{n24}
Treatment Group 3 C.A.L. - Mathematics	1	X_{131}	X_{132}	X_{133}	X_{134}
	2	X_{231}	X_{232}	X_{233}	X_{234}
	3	X_{331}	X_{332}	X_{333}	X_{334}
	⋮	⋮	⋮	⋮	⋮
	n	X_{n31}	X_{n32}	X_{n33}	X_{n34}

APPENDIX F

MEANS AND STANDARD DEVIATIONS

APPENDIX F

RAW DATA SUMMARY TABLES

(Elementary Ss-Word Meaning)

	Language Arts Group (a_1)			
Ss	Pre 1	Pre 2	Post	Retention
1	2.3	2.0	2.1	2.5
2	2.0	2.3	2.6	2.7
3	1.8	2.0	2.7	2.3
4	1.8	2.1	2.7	2.7
5	1.8	2.6	2.6	2.7
6	2.3	2.6	2.3	2.5
7	1.9	2.5	2.9	1.8
8	2.3	2.3	3.2	3.2
9	2.5	2.4	2.9	3.6
10	1.5	1.7	1.9	1.8
11	1.8	1.8	2.4	2.4
12	1.7	1.6	1.8	2.0
13	1.5	1.6	1.7	1.5
Totals	25.2	27.5	31.8	31.7
Means	1.94	2.12	2.45	2.44
S.D.	0.32	0.37	0.46	0.58
$(S.D.)^2$	0.10	0.13	0.21	0.34

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Word Meaning)

Combined Group (a_2)				
Ss	Pre 1	Pre 2	Post	Retention
1	1.4	1.5	1.6	1.7
2	1.7	1.6	1.6	1.6
3	1.5	1.6	1.6	1.8
4	1.9	1.5	1.8	1.8
5	1.4	1.7	1.7	1.5
6	2.2	1.7	1.9	1.8
7	1.9	1.8	2.4	2.5
8	1.4	1.1	1.4	1.4
9	1.7	1.4	1.6	1.7
10	1.2	1.4	1.4	1.4
11	1.7	1.4	2.1	2.4
12	1.6	1.2	1.3	2.2
13	1.5	1.4	1.5	1.5
14	1.8	2.2	2.6	2.7
15	1.4	1.5	1.5	1.5
16	1.6	1.4	1.7	1.7
17	1.7	1.9	2.1	2.3
Totals	27.6	26.3	29.8	31.5
Means	1.62	1.55	1.75	1.85
S.D.	0.24	0.26	0.36	0.41
$(S.D.)^2$	0.06	0.07	0.13	0.17

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Word Meaning)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	1.8	1.8	2.1	2.0
2	1.4	1.0	1.3	1.4
3	1.7	1.3	1.7	1.7
4	1.6	1.4	1.7	1.6
5	1.9	1.7	1.9	2.0
6	1.7	1.7	1.7	1.8
7	1.7	1.8	1.6	1.7
8	2.0	1.8	2.1	1.9
9	1.8	1.9	2.2	2.3
Totals	15.6	14.4	16.3	16.4
Means	1.73	1.60	1.81	1.82
S.D.	0.17	0.30	0.29	0.26
$(S.D.)^2$	0.03	0.09	0.08	0.07

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Word Meaning)

	Language Arts Group (a_1)			
Ss	Pre 1	Pre 2	Post	Retention
1	2.3	2.3	2.4	2.7
2	2.4	1.8	2.2	2.2
3	2.2	2.5	2.6	2.4
4	2.4	1.9	2.6	1.8
5	4.7	4.7	5.2	4.7
6	4.4	3.0	4.7	4.2
7	6.7	7.1	8.5	7.8
8	3.3	3.2	3.2	3.1
9	3.6	3.0	3.6	3.9
10	2.7	3.1	3.3	3.9
Totals	34.7	32.6	38.3	36.7
Means	3.47	3.26	3.83	3.67
S.D.	1.44	1.58	1.91	1.73
$(S.D.)^2$	2.08	2.50	3.66	3.01

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Word Meaning)

Combined Group (a_2)				
Ss	Pre 1	Pre 2	Post	Retention
1	2.7	2.6	3.6	3.6
2	3.6	3.5	3.6	3.6
3	1.9	1.7	2.0	1.8
4	2.7	2.8	2.7	2.9
5	2.1	2.3	1.9	2.0
6	1.8	1.7	2.1	2.4
7	2.7	2.6	2.7	3.2
8	2.3	2.5	2.7	2.6
9	3.9	3.9	3.8	4.2
10	4.7	3.9	5.1	4.4
11	4.2	3.9	3.5	3.5
12	3.3	3.3	3.2	3.6
Totals	35.9	34.7	36.9	37.8
Means	2.99	2.89	3.08	3.15
S.D.	0.94	0.80	0.92	0.82
$(S.D.)^2$	0.89	0.65	0.84	0.70

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Word Meaning)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	4.1	3.0	4.7	3.5
2	3.2	2.9	2.7	3.0
3	2.3	3.0	3.1	3.2
4	1.8	2.0	2.7	2.1
5	1.8	1.8	2.5	2.7
6	3.2	3.0	3.1	3.3
7	1.9	2.7	3.5	2.8
8	1.8	2.5	2.0	2.1
Totals	20.1	20.9	24.3	22.7
Means	2.51	2.61	3.04	2.84
S.D.	0.88	0.48	0.81	0.52
$(S.D.)^2$	0.77	0.23	0.65	0.27

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Paragraph Meaning)

Language Arts Group (a_1)				
Ss	Pre 1	Pre 2	Post	Retention
1	2.4	1.8	2.9	2.4
2	2.7	2.6	2.6	2.6
3	2.4	2.0	2.3	2.5
4	2.5	2.1	2.1	2.0
5	2.4	2.6	2.5	2.9
6	2.4	2.5	2.5	2.4
7	2.1	1.9	2.6	2.5
8	1.9	1.7	1.7	1.8
9	1.8	1.7	2.1	2.1
10	1.6	1.6	1.6	1.6
11	1.7	1.6	1.7	1.8
12	1.7	1.6	1.7	1.7
13	1.6	1.5	1.5	1.5
Totals	27.2	25.2	27.8	27.8
Means	2.09	1.94	2.14	2.14
S.D.	0.39	0.40	0.46	0.46
$(S.D.)^2$	0.15	0.16	0.21	0.21

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Paragraph Meaning)

Combined Group (a_2)				
Ss	Pre 1	Pre 2	Post	Retention
1	1.6	1.7	1.6	1.7
2	1.7	1.7	1.6	1.6
3	1.6	1.6	1.4	1.6
4	1.4	1.3	1.4	1.2
5	1.5	1.4	1.6	1.4
6	1.6	1.7	1.6	1.6
7	1.6	1.7	1.9	1.8
8	1.6	1.6	1.7	2.0
9	1.6	1.6	1.6	1.6
10	1.5	1.4	1.9	1.8
11	1.5	1.6	1.7	1.6
12	1.8	1.7	1.8	1.6
13	1.6	1.5	1.6	1.6
14	1.4	1.4	1.5	1.7
15	1.8	1.6	1.6	1.6
Totals	23.8	23.5	24.5	24.4
Means	1.59	1.57	1.63	1.63
S.D.	0.12	0.14	0.15	0.18
$(S.D.)^2$	0.01	0.02	0.02	0.03

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Paragraph Meaning)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	1.6	1.7	1.7	1.7
2	1.2	1.5	1.3	1.5
3	1.6	1.7	1.4	1.7
4	1.5	1.5	1.7	1.7
5	1.9	1.7	1.7	1.7
6	1.6	1.7	1.6	1.6
7	1.6	1.4	1.3	1.4
8	1.7	1.7	1.8	1.8
9	1.7	1.7	1.6	1.7
Totals	14.4	14.6	14.1	14.8
Means	1.60	1.62	1.57	1.64
S.D.	0.19	0.12	0.19	0.12
$(S.D.)^2$	0.04	0.01	0.04	0.02

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Paragraph Meaning)

Language Arts Group (a_1)				
Ss	Pre 1	Pre 2	Post	Retention
1	2.1	1.8	2.4	1.8
2	1.9	1.8	2.2	1.9
3	1.9	1.8	1.7	1.8
4	2.1	1.9	1.8	1.8
5	6.3	6.6	6.6	5.6
6	5.4	5.0	4.2	5.4
7	5.6	4.8	5.0	4.3
8	4.6	4.1	4.3	4.7
9	6.4	8.0	6.2	7.0
10	2.7	3.8	2.7	2.7
11	2.7	2.7	3.4	2.5
12	2.3	2.4	2.2	2.4
Totals	44.0	44.7	42.7	41.9
Means	3.67	3.73	3.56	3.49
S.D.	1.83	2.06	1.70	1.82
$(S.D.)^2$	3.36	4.25	2.87	3.31

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Paragraph Meaning)

Combined Group (a_2)				
Ss	Pre 1	Pre 2	Post	Retention
1	2.6	2.4	2.5	2.5
2	3.6	3.5	2.7	3.1
3	1.6	1.5	1.8	1.8
4	2.0	2.1	2.5	2.6
5	1.8	1.6	2.0	2.3
6	1.8	1.7	1.8	1.8
7	2.3	2.0	2.2	2.5
8	2.4	2.1	2.5	2.3
9	4.4	3.0	3.9	4.1
10	4.3	4.3	4.9	3.2
11	3.2	3.0	4.6	3.0
12	3.8	4.0	4.1	3.8
Totals	33.8	31.2	35.5	33.0
Means	2.82	2.60	2.96	2.75
S.D.	1.01	0.95	1.11	0.72
$(S.D.)^2$	1.01	0.90	1.23	0.52

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Paragraph Meaning)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	3.4	4.1	4.1	4.1
2	2.8	2.9	2.8	3.7
3	2.5	1.9	2.9	2.6
4	3.1	2.4	2.6	2.6
5	1.9	1.8	1.9	2.3
6	2.9	3.4	3.3	3.1
7	3.1	2.9	3.4	3.4
8	2.0	1.8	2.5	2.7
Totals	21.7	21.2	23.5	24.5
Means	2.71	2.65	2.94	3.06
S.D.	0.54	0.83	0.67	0.63
$(S.D.)^2$	0.29	0.69	0.44	0.39

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Arithmetic)

Language Arts Group (a_1)				
Ss	Pre 1	Pre 2	Post	Retention
1	2.9	2.9	3.1	3.7
2	2.8	2.8	3.6	3.8
3	2.9	3.0	3.9	4.0
4	1.9	2.1	2.3	2.5
5	2.7	2.0	3.4	3.5
6	2.9	2.6	2.7	3.4
7	2.9	3.0	3.0	3.3
8	1.5	1.5	1.6	1.6
9	1.6	1.6	1.6	1.6
10	1.6	1.6	1.6	1.6
11	1.7	1.6	1.6	1.6
12	1.6	1.5	1.6	1.6
13	1.5	1.5	1.4	1.5
Totals	28.5	27.7	31.4	33.6
Means	2.19	2.13	2.42	2.59
S.D.	0.64	0.63	0.91	1.04
$(S.D.)^2$	0.41	0.40	0.82	1.08

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Arithmetic)

Combined Group (a_2)

Ss	Pre 1	Pre 2	Post	Retention
1	1.4	1.4	1.5	1.6
2	1.5	1.4	1.6	1.6
3	1.1	1.1	1.5	1.6
4	1.3	1.4	1.5	1.5
5	1.3	1.4	1.4	1.4
6	1.5	1.5	1.6	1.6
7	1.4	1.3	1.6	1.6
8	1.5	1.6	1.6	1.6
9	1.3	1.3	1.1	1.4
10	1.2	1.2	1.4	1.5
11	1.3	1.3	1.6	1.6
12	1.6	1.5	1.5	1.6
13	1.2	1.0	1.2	1.4
14	1.4	1.5	1.5	2.6
Totals	19.0	18.9	20.6	22.6
Means	1.36	1.35	1.47	1.61
S.D.	0.14	0.17	0.15	0.30
$(S.D.)^2$	0.02	0.03	0.02	0.09

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Elementary Ss-Arithmetic)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	1.2	1.2	1.5	1.5
2	1.0	1.1	1.2	1.2
3	1.4	1.2	1.4	1.5
4	1.4	1.5	1.4	1.5
5	2.4	1.3	2.4	1.6
6	2.3	1.7	2.6	2.1
7	1.5	1.5	1.5	1.4
8	2.0	1.7	2.9	3.5
9	2.0	2.2	2.1	3.0
10	1.8	1.6	2.5	2.4
Totals	17.0	15.0	19.5	19.7
Means	1.70	1.50	1.95	1.97
S.D.	0.47	0.33	0.62	0.77
$(S.D.)^2$	0.22	0.11	0.38	0.59

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Arithmetic)

Language Arts Group (a_1)				
Ss	Pre 1	Pre 2	Post	Retention
1	1.5	1.6	1.5	1.6
2	1.6	1.5	1.6	1.6
3	1.5	1.6	1.6	1.6
4	1.6	1.6	1.6	1.6
5	10.0	10.0	10.8	7.9
6	8.2	6.6	7.6	6.3
7	7.1	6.3	8.4	7.8
8	8.5	7.8	9.6	12.6
9	7.1	7.1	7.9	8.4
10	3.9	3.5	4.8	4.4
11	5.7	4.5	5.8	5.1
12	5.1	4.4	5.7	4.8
Totals	61.8	56.5	66.9	63.7
Means	5.15	4.71	5.58	5.31
S.D.	3.10	2.87	3.38	3.47
$(S.D.)^2$	9.58	8.21	11.43	12.07

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Arithmetic)

Combined Group (a_2)

Ss	Pre 1	Pre 2	Post	Retention
1	3.7	3.6	3.8	4.2
2	3.8	3.3	4.3	4.3
3	2.7	1.9	3.0	2.8
4	3.9	3.0	4.3	4.5
5	2.9	2.6	3.7	4.2
6	3.9	3.6	2.5	3.3
7	4.0	3.7	4.6	4.9
8	4.5	4.3	5.2	5.2
9	5.6	5.4	5.9	5.4
10	3.8	4.1	5.0	5.0
11	3.7	4.1	4.1	3.8
12	6.6	7.1	6.5	7.1
Totals	49.1	46.7	52.9	54.7
Means	4.09	3.89	4.41	4.56
S.D.	1.07	1.34	1.14	1.11
$(S.D.)^2$	1.15	1.80	1.29	1.22

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Arithmetic)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	5.8	4.4	6.5	5.9
2	2.9	3.3	3.7	4.0
3	3.8	2.7	3.7	3.6
4	3.3	3.8	3.6	3.7
5	3.9	3.8	3.2	2.7
6	3.5	3.6	5.2	6.2
7	5.1	4.9	6.2	6.2
8	5.0	4.6	5.3	7.5
9	1.5	1.5	1.5	1.5
Totals	34.8	32.6	38.9	41.3
Means	3.87	3.62	4.32	4.59
S.D.	1.30	1.04	1.60	1.96
$(S.D.)^2$	1.69	1.09	2.56	3.83

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Language)

Language Arts Group (a_1)				
Ss	Pre 1	Pre 2	Post	Retention
1	8.2	7.6	8.4	7.7
2	7.8	7.5	7.9	7.5
3	4.8	3.9	5.1	4.9
4	6.0	5.8	5.5	5.4
5	9.7	8.2	9.7	9.8
6	2.7	2.7	3.2	2.8
7	2.4	3.1	3.5	2.4
8	3.1	2.7	2.5	3.0
Totals	44.7	41.5	45.8	43.5
Means	5.59	5.19	5.73	5.44
S.D.	2.78	2.36	2.67	2.69
$(S.D.)^2$	7.73	5.57	7.12	7.26

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Language)

Combined Group (a_2)				
Ss	Pre 1	Pre 2	Post	Retention
1	4.1	4.6	3.6	5.1
2	3.2	2.7	3.1	4.0
3	4.8	3.2	4.0	4.8
4	4.8	2.9	4.1	4.7
Totals	16.9	14.4	14.8	18.6
Means	4.23	3.60	3.70	4.65
S.D.	0.76	0.83	0.46	0.46
$(S.D.)^2$	0.58	0.69	0.21	0.22

APPENDIX F (cont'd.)

RAW DATA SUMMARY TABLES

(Senior Ss-Language)

Mathematics Group (a_3)				
Ss	Pre 1	Pre 2	Post	Retention
1	2.6	2.7	2.6	3.2
2	2.9	2.8	3.4	2.9
3	2.7	2.8	3.8	3.0
4	2.1	1.9	2.2	2.1
5	4.2	3.3	4.2	4.5
6	2.5	2.5	3.1	3.4
7	2.7	2.3	2.3	2.6
Totals	19.7	18.3	21.6	21.7
Means	2.81	2.61	3.09	3.10
S.D.	0.66	0.44	0.76	0.75
$(S.D.)^2$	0.44	0.20	0.58	0.56

APPENDIX G

SUMMARY TABLE OF MEANS

APPENDIX G

SUMMARY TABLE OF MEANS
FOR ELEMENTARY Ss

Word Meaning

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	1.94	2.12	2.45	2.44	2.23
Combined	1.62	1.55	1.75	1.85	1.69
Arithmetic	1.73	1.60	1.81	1.82	1.74
$\overline{X}$	1.75	1.75	2.00	2.04	1.89

Paragraph Meaning

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	2.09	1.94	2.14	2.14	2.08
Combined	1.59	1.57	1.63	1.63	1.60
Arithmetic	1.60	1.62	1.57	1.64	1.61
$\overline{X}$	1.77	1.71	1.79	1.81	1.77

Maths

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	2.19	2.13	2.42	2.59	2.33
Combined	1.36	1.35	1.47	1.61	1.45
Arithmetic	1.70	1.50	1.95	1.97	1.78
$\overline{X}$	1.74	1.66	1.93	2.05	1.85

SUMMARY TABLE OF MEANS FOR
SENIOR Ss

Word Meaning

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	3.47	3.26	3.83	3.67	3.56
Combined	2.99	2.89	3.08	3.15	3.03
Arithmetic	2.51	2.61	3.32	2.84	3.13
$\overline{X}$	3.02	2.94	3.32	3.24	3.13

Paragraph Meaning

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	3.67	3.73	3.56	3.49	3.61
Combined	2.82	2.60	2.96	2.75	2.78
Arithmetic	2.71	2.65	2.94	3.06	2.84
$\overline{X}$	3.11	3.03	3.18	3.11	3.11

Maths

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	5.15	4.71	5.58	5.31	5.19
Combined	4.09	3.89	4.41	4.56	4.24
Arithmetic	3.87	3.62	4.32	4.59	4.10
$\overline{X}$	4.42	4.12	4.81	4.84	4.54

Language

	Pre 1	Pre 2	Post	Ret.	$\overline{X}$
Language Arts	5.59	5.19	5.73	5.44	5.48
Combined	4.23	3.60	3.70	4.65	4.04
Arithmetic	2.81	2.61	3.09	3.10	2.90
$\overline{X}$	4.28	3.91	4.33	4.41	4.23