AN ABSTRACT OF THE THESIS OF

Vasantha Sunandini Cola for the degree of Doctor of Philosophy in Education presented on June 12, 1985.

Title: Using Selected Computer Games as an Instructional Strategy with Learning Disabled Adolescents to Improve Achievement in Arithmetic Facts.

Abstract approved Redacted for privacy
Thomas P. Evans, Ph.D.

The use of selected computer games was studied as an intervention technique in an attempt to increase achievement of learning disabled adolescents in basic multiplication and division facts. A multiple baseline design across subjects with a follow-up was employed in an applied behavioral setting. The subjects were two female and two male learning disabled adolescents enrolled in a public high school. Achievement was measured using investigator-made tests. The number of correct responses made during baseline and intervention phases were recorded on graphs.

Results indicated that selected computer games were effective as an instructional strategy for these learning disabled students who had poor knowledge of multiplication and division facts. The students demonstrated improved

performance and maintained this performance level thirty days after the intervention was discontinued.

It was concluded that selected computer games provide a viable supplement to classroom instruction as a means of improving learning disabled adolescents' achievement in multiplication and division facts.

Using Selected Computer Games as an Instructional Strategy with Learning Disabled Adolescents to Improve Achievement in Arithmetic Facts

by

Vasantha Sunandini Cola

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed June 12, 1985

Commencement June 1986

APPROVED:

Redacted for privacy

Professor of Science, Mathematics and Computer Science Education in charge of major

Redacted for privacy

Head of Department of Science, Mathematics and Computer Science Education

Redacted for privacy

Dean of Graduate School

Date thesis is presented June 12, 1985

Typed by Sessions Typing Service for Vasantha Cola

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my major professor Dr. Thomas Evans for his advice and guidance in conducting this study and in preparation of the thesis.

Sincere thanks are extended to Dr. G. Craven, Dr. F. Cross, Dr. M. Giblin, Dr. D. Fahey and Dr. J. Krueger.

My deepest gratitude to my mother Rukmine Rajyalaxmi for her faith in me.

TABLE OF CONTENTS

TABLE OF CONTENTS

(continued)

TABLE OF CONTENTS

(continued)

LIST OF FIGURES

LIST OF FIGURES

(continued)

LIST OF TABLES

Using Selected Computer Games as an Instructional Strategy with Learning Disabled Adolescents to Improve Achievement in Arithmetic Facts

I. INTRODUCTION

Learning disabled adolescents, as defined by Public Law 94-142, are youth of normal intelligence who exhibit a disorder in one or more of the basic psychological process that affect listening, reading, writing, spelling and arithmetic. Public Law 94-142 also states that the learning disabled adolescent should be placed in a regular classroom and given support service in a resource room.

Learning disabled adolescents who are placed in regular classrooms are expected to meet all the curriculum demands placed on all students. They not only must learn, integrate, and express content information but they must develop skills in academic and nonacademic situations. It is essential that new instruction strategies be developed to facilitate skill development for these individuals.

One of the instructional strategies unique to special education is remediation. Unfortunately, remediation presented to learning disabled adolescents in secondary schools has focused mainly on reading and communication skills (Marsh, Gearheart & Gearheart, 1978) and very little on arithmetic facts. A knowledge of arithmetic facts is crucial to the maturing learning disabled adolescent since, in the near future, he or she will need to deal effectively with salespersons, insurance agents, bankers, and others in the course of handling personal affairs. Arithmetic facts must be utilized in order to perform routine computations, such as balancing the checkbook, paying bills, planning a budget, or validating a paycheck (Alley & Deshler, 1979). The adolescent who lacks this working knowledge of arithmetic facts will be at a strong disadvantage. The greater the number of facts (skills and abilities) that an adolescent lacks, the less he/she is able to compensate for any given deficiency (Alley, Deshler & Warner, 1977). It is apparent, therefore, that there is need for an instructional strategy for learning disabled adolescents which focuses primarily on improvement in arithmetic skills.

The development of electronic computers in the late forties, combined with their present day sophistication and accessibility, has unquestionably made a significant contribution to the emergence of education games (Bowman, 1982). Playing computer games utilizes conscious, deliberate mental and physical activity. The games promote active learning by shifting players into participant roles, because each strategic movement generates a visible response (Bowman, 1982).

Although slow to utilize computer games, educators are beginning to realize that the use of game format as an instructional technique may provide a way to motivate adolescents and raise their academic achievement levels. For adolescents who have learning problems, the game format can facilitate the practice of arithmetic facts and operations. Computer games enable the poor learner to minimize or circumvent significant barriers to learning. Students who are able to understand basic math concepts but unable to do error-free calculations (due to poor memory or perceptual, visual, and/or other problems) can manipulate numbers in a computer game with greater ease and accuracy. Also, use of computers motivates adolescents to reduce errors (spelling, writing, and computing errors), since the computer displays their errors in a nonthreatening way. Most important the adolescent who is otherwise unable to produce acceptable work can use the computer to demonstrate his/her productivity to himself/herself and others (Budoff, Thorman & Gras, 1984).

Statement of the Problem

The problem of this study was to investigate the use of computer games as an intervention technique that will result in a higher achievement level in computation of multiplication and division facts for learning disabled adolescents.

Need for the Study

There is not much information available in the professional literature concerning the arithmetic needs of the learning disabled adolescent (Lerner, 1976; Mercer, 1979). Traditionally, arithmetic facts have been taught through drill and practice methods. The teacher presents the student with a worksheet or dittoed page. At the end of the arithmetic period, the worksheet is collected and graded. This traditional method may not be the most efficacious for the teacher of special education. The student who has difficulty in learning arithmetic facts does not understand a concept after only one or two exposures to the task; repeated exposures to the task are necessary (Kennedy & Michon, 1973). Also, the learning disabled student will not be helped merely by repetition, but must be exposed to a wide variety of visual and symbolic approaches to increase understanding. Using the rote memory method (i,e., worksheets) to teach arithmetic facts to the learning disabled student may not be the most effective approach (Cawley, Fitzmaurice, Kahn, and Bates, 1978; Johnson, 1979).

The learning disabled student should be an active participant in the learning process. He/she needs to manipulate the objects used in the instruction, rather than passively observing other class members performing the given task (Kennedy & Michon, 1973). Active participation allows the learning disabled student to learn from the content of the activity as well as from the other students (Bar-Adon, 1971).

Game activities afford active manipulation and participation and advanced technology has contributed a fresh social phenomenon--computer games. Computer game programs provide direct interactive individualized instruction, allow a student to learn at his/her own rate, "remember" student's responses, provide instant feedback, and give a variety of reinforcements.

In recent years, there has been an increasing interest in research on the effects of computer games. However, few studies have been conducted to determine the instructional value of computer games, and those studies that have been conducted have involved normal children (Chaffin & Ruggles, 1982; Prigger,1982). There is little research evidence on which to support the educational value of computer games. Any casual observer can produce anecdotal, impressionistic data supporting the educational value of the games, but organized, systematic studies are absent. The lack of research is even more conspicuous in the area of special education.

In sum, learning disabled adolescents need much repetition, a wide variety of approaches, and active participation in order to learn. Traditional methods of teaching arithmetic often lack these necessary ingredients. Since computer games supply these three ingredients, they could be worthwhile tools for teaching arithmetic to learning disabled students. There is much subjective, but little organized, scientific study of the use of computer games as a viable teaching method.

Assumptions

1. Learning disabled adolescents can be taught basic multiplication and division facts.
2. Traditional methods of teaching arithmetic facts to learning disabled adolescents have generally been ineffective.
3. Knowledge of division and multiplication facts are important to learning disabled adolescents if they are to function adequately in a scientific and technological society.
4. The procedure used by South Albany High School is a valid and reliable method for selecting learning disabled adolescents.

Limitations

Limitations of the study are as follows:

1. The study is limited to students who were identified by a school psychologist as being learning disabled.
2. The study is limited to the technical facilities and equipment available in the classroom.
3. The study is limited by the validity and reliability of the investigator-made achievement tests on multiplication and division facts.

Delimitations

Delimitations of the study are as follows:

1. The subjects are four learning disabled students enrolled in ninth grade at South Albany High School, Albany, Oregon.
2. The computer games focus only on multiplication and division facts.
3. The study does not compare other computer games to those from Arc-ed software.

Definition of Terms

Baseline is a pre-experimental record of behavior. In this study, the baseline record of each adolescent is the number of multiplication or division facts scored correctly by each student during drill activities prior to the experiment.

Computer games are defined as Meteor Multiplication (serial no. L1311) and Demolition Division (serial no. L1411). These games are marketed by DLM, Inc. under the trade name of Academic Skillbuilders.

Drill and Practice is a method of teaching based exclusively on repetition (Monroe, 1968). For the purpose of this study, worksheets consisting of ten problems of multiplication and division facts, using numbers 0 through 9, are used. The drill activities were completed independent of teacher supervision by the student working alone at his/her desk.

Intervention is the treatment consisting of playing five computer games each in multiplication and division facts, four times a week.

Learning disabled adolescent: is an adolescent of normal intelligence who exhibits a disorder in one or more of the basic psychological processes involved in understanding or in using spoken and written language. The disorder can be manifested as a problem in listening, thinking, reading, talking, writing, spelling, or doing arithmetic. The disorder is not due primarily to a visual, hearing, or motor handicap; mental retardation; emotional disturbance; or environmental deprivation.

Learning disabled student is a student 12 to 21 years of age diagnosed as learning disabled by a school psychologist (Schmid, 1979).

Stability is a condition where there is little change in the baseline measurement of the subject, i.e., little change in the percentage of problems worked correctly from day to day.

Student Achievement is the difference between the students' pre-tests and post-tests scores on investigator-made tests measuring knowledge of multiplication and division facts.

Target behavior is the behavior to be changed, i.e. student's performance on tests designed to measure knowledge of multiplication and division facts.

Methodology

The subjects are four learning disabled adolescents sixteen to eighteen years of age, enrolled in ninth grade at South Albany High School, Albany, Oregon. These students have been selected on the basis of their lack of proficiency in multiplication and division facts. The study will be conducted in the resource room of the South Albany High School. The materials to be used are an Apple computer, computer games software, and worksheets of drill activities in multiplication and division facts.

A multiple baseline design across subjects has been used as the research design. In this design, a particular behavior common to the four subjects is observed and baseline data are gathered regarding that behavior. After the identified behavior for each subject becomes stable (establishment of baseline), intervention is applied to one subject's behavior while baseline conditions are continued for other(s). The behavior of the subject exposed to intervention is expected to change; the behaviors of the others are expected to continue at baseline levels. This procedure is continued until all of the subjects for whom baseline data have been collected receive the intervention. The effect of the intervention is demonstrated when a change in each subject's performance is obtained at the point when intervention is introduced and not before. This design is becoming popular in clinical and educational settings (Bornstein & Quevillon, 1976; Gruber, Reeser & Reid, 1979; Sowers, Rusch & Cummings, 1980).

The dependent variables in this study are the student scores on the investigator-designed multiplication and division tests, and drill activities. The independent variables are instruction in multiplication and division facts by means of selected computer games.

Each subject will be pre-tested at the beginning of winter term 1984. The pre-test developed by the investigator, consists of 50 multiplication fact items and 50 division fact items randomly selected from intervention computer games (Meteor Multiplication and Demolition Division). The time limit for the pre-test is five minutes. After the pre-test, the subjects will be given worksheets consisting of drill activities in multiplication and division facts. Each drill activity consists of ten multiplication facts and ten division facts and has a time limit of two minutes. Baseline data will be recorded for each subject. During worksheet activity, no instruction or feedback will be provided.

As soon as baseline data reach stability for any one of the subjects, training sessions with the computer games will begin for that subject. Training sessions continue until the subject is able to operate the computer and play the games himself/herself. After the training session, intervention will be implemented. During the intervention phase, the subject will play five games per skill, four times a week. The intervention phase has the same duration as the baseline phase (i.e., an equal number of data points exist in both phases). If no improvement is seen or if there is a broad range of variability in the occurrence of behavior, the length of the intervention phase will be extended for the subject. Data will be recorded for the subject throughout the intervention phase. Meanwhile, baseline data will continue to be recorded for the other three subjects. Data will be collected at the same time of day during the baseline and intervention phases of this study.

One week later, after the first subject has completed the intervention phase, training and intervention will be implemented for the second subject, in the same manner as the first, while baseline data continue to be collected for the remaining two subjects. Since the remaining subjects will have an extended (prolonged) baseline, intermittent assessment of drill activities will be conducted three times a week to obtain baseline data for the third and fourth subjects.

Each subject will be post-tested at the end of the intervention phase. The pre-test and post-test are identical.

The data collected for each subject will be graphically represented, and the means for baseline and intervention will be calculated and interpreted.

Reliability of the pre-test/post-test will be independently rated rated by a research assistant at Oregon State University, a resource teacher at South Albany High School, and the investigator.

The same raters will independently rate reliability of the baseline data, using the permanent product record method.

Maintenance, or generalization across time, is regarded as the length in time the effects of intervention are maintained (Baer, Wolf & Risley, 1968). The efficiency of the intervention process is highly dependent on the systematic evaluation and measurement of the training period(s) for each student. In this study, maintenance of intervention effects for each subject will be tested thirty days after the termination of intervention, using the same investigator-designed test that was used as pre-test.

Organization of Remainder of Study

Chapter I has introduced the study by (1) developing a need by means of a literature review in the area of learning disabled adolescents and computer games as a teaching aide (2) presentation of the study problem, and methodology.

Chapter II reviews literature pertainin to learning disabilities, learning disabled adolescent, computer games and multiple baseline across subjects.

Chapter III presents the methodology of the study. It includes a discussion of characteristics of each subject, setting, materials, experimental design, and research procedures.

Chapter IV presents the findings of the study. Reliability data from pre- and post-tests as well as each subject's baseline, intervention and maintenance data, are discussed. The overall performance of subjects with respect to multiplication and division facts are discussed.

Chapter V presents a summary, conclusions, and discussion of the appropriateness of the multiple baseline design across subjects. It also includes recommendations for classroom practice and further study.

II. LITERATURE REVIEW

The literature will be reviewed in three sections. The first section provides a brief historical overview of learning disabilities and a description of the characteristics of learning disabled adolescents.

The second section describes the general characteristics of computer games, their uses in general classrooms, and their benefits for learning disabled students.

The third section describes the multiple baseline research design and its underlying rationale, advantages, and problems. Multiple baseline design across subjects, a variation of multiple baseline design used in this study, is also described.

Learning Disabilities

Historical Overview

The historical antecedents of the term "learning disabilities" account for much of the confusion that surrounds the definition. Before the term was accepted, many definitions were used synonymously to describe those children whose learning and behavior patterns did not quite fit existing definitions of handicaps. The idea that the mind was subdivided into traits or mental processes gained slow acceptance and essentially evolved from attempts to explain the various brain functions now associated with cognition, i.e., language, perception, memory, etc. For several centuries, argument flourished among scholars regarding localization of brain function. The British empiricists-associationists introduced the information processing theory as an alternative to Descartes's doctrine of innate learning of the Seventeenth Century. The German psychologist, Wolfe (1679-1754), introduced a psycho-neurological study of how cerebral lesions affected localized areas of the central nervous system. This thesis was expanded by a Viennese physician, Gall (1758-1828), who reasoned that damage to a certain area of the brain would result in loss of a specific function. Gall's belief in localization was so strong that he even postulated that intelligence could be determined by measuring the protrusions of the skull. This view resulted in the birth of the science of phrenology.

Gall's beliefs in mental processes and phrenology were challenged by one of Germany's leading psychologists, George Frederick Herbart (1774-1841), who contended that the brain worked as a unit. Herbart was so persuasive that Wundt (1832-1920), the father of experimental psychology, disregarded cognition in favor of structuralism.

Many early special educators depended on psychometric tests for classification and placement of children. They also believed that disabilities were related specifically to brain area function; thus, they supported the basic mental processes theory.

Pestalozzi (1747-1827), Bastian (1887), and Jackson (1915), using research in speech, epilepsy, and sensory functions, devised maps of localized brain function. Itari, Seguin, Montessori, Fernald and Descoendres continued the practice of modality training with handicapped children. The work of Goldstein, Strauss, and Werner in the 1940s and 50s drew parallels between brain damage and perceptual-motor disturbance.

The 1960s were referred to as the perceptual-motor era. Researchers such as Kephart, Barsh, Getman Frostig, and Cruickshank devised teaching methods for children who were assumed to be brain damaged, and who performed poorly on perceptual-motor tests.

Twenty five years later people, such as Strauss, Monroe, Lehtinen, Gillingham, and Kirk, did research, taught, and prepared others to teach, using mental process training techniques (motor, perceptual, and language). Thus, an information-processing approach became a strong influence in defining handicapping conditions.

Until 1963, children who performed poorly in school and on perceptual-motor tests were diagnosed as brain damaged.

In fact, the diagnostic term used was "minimal brain dysfunction" (Chalfant and Scheffefin 1969). The symptoms, (hyperactivity, distractibility, poor motor control, short attention span, and impulsiveness) typically observed in victims of brain damage, are typical symptoms of the learning disabled. Unfortunately, no direct measure of minimal brain damage dysfunction exists that can reliably differentiate the learning disabled from normal individuals.

An historic moment came on April 6, 1963, when Kirk addressed the parent group responsible for the Fund for Perceptually Handicapped Children, Inc., (the predecessor to the Association for Children with Learning Disabilities). For the first time, the term "learning disabilities" was used in public forum. Kirk questioned the relevance of a search for neurological signs when, in fact, diagnosis of minimal brain injury resulted from an absence of such findings. He was even more critical of the idea of instructional and behavioral management based on the diagnostically useless term--minimal brain damage.

Kirk's speech resulted in the formation of the Association for children with Learning Disabilities and the widespread use of the term "learning disabled". In 1968, the National Advisory Committee on Handicapped Children developed a definition which became widely used because of its inclusion in P.L. 91-230, a 1969 agreement amendment to the Elementary and Secondary Education Act (ESEA, Title VI, of the Education of the Handicapped Act of 1967).

The current commonly accepted definition of learning disabilities is found in P.L. 94-142 which defines learning disabilities as disorders in one or more of the basic physiological processes involved in understanding or in using language spoken or written, which may manifest themselves in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia. It does not include children who have learning problems which are primarily the result of visual, hearing, motor handicaps, mental retardation, emotional disturbance, environmental, cultural, or economic disadvantage. (USOE, 1977, p. 65083, published in the Federal Register)

Because the definition of learning disabilities, as well as its assessment and diagnostic procedures, varies so widely, there are no reliable distribution figures. Estimates range up to 30 percent of the school-age population. In 1981-1982 the Department of Education identified 3.33 percent of the children from age 5 to 17 as learning disabled.

Characteristics of Learning Disabled Adolescents

Interest in the learning disabled adolescent has increased in recent years. Educators have realized that, though improvement occurred when the student received extensive remediation at the elementary level, many learning disabled adolescents continued to lag academically and socially. This lag was related to the characteristics associated with adolescence.

Current information about the characteristics of learning disabled adolescents is derived from clinical data and classroom observations. Numerous lists of characteristics exist resulting from the populations studied and from the judgment of observers. It is difficult to compare results or to draw conclusions from research and observational findings.

Deshler (1975, 1978) identified four types of behavioral symptoms which continue into adolescence. These adolescents exhibit characteristics previously observed in SLD children but which are displayed in more subtle fashion during adolescence, continuing problems in reading and mathematics, poor self concept and motivation, and difficulties in social and emotional areas.

Schmid (1979) noted four general characteristics with many sub-characteristics. (See Appendix A). Many items in Appendix A refer to continuing problems in information-processing, academics, physical development, and socio-emotional differences.

In 1980, studies dealing with academic-cognitive, personality-social, and perceptual-motor factors involved in learning disabilities were reviewed by Deshler and he noted that by the time the learning disabled child reached adolescence, there was a high probability that the indirect effects of having a learning handicap would result in poor self-perception, lowered self-concept, and reduced motivation. At the same time, the former characteristics of uncoordination, hyperactivity, distractibility, and poor attention were manifested in more subtle fashions.

Recently, characteristics of learning disabilities were documented through research conducted by University of Kansas Institute for Research in Learning Disabilities. This research was funded by the U.S.O.E office of Special Education and Rehabilitative Services in 1978. The Institute specified the learning disabled adolescent and young adult as its target population. Its commitment was to the development of a comprehensive data base as a strategy for describing learning disabilities. It was hoped that the resulting description would serve as a basis for the design and validation of intervention and support systems that would enhance the adolescent's performance in school, home, community, and employment settings. (See Appendix B.)

In summary, the historical overview of learning disabilities and the recent investigation of the characteristics of learning disabled adolescent in recent empirical research continue to substantiate the notion of a heterogeneous group, which for classification purposes has been labeled learning disabled.

In reality, this group may exhibit clusters of characteristics. Thus it is likely that by nature of conditions, any attempts to form a list might include information-processing deficits, academic difficulties, developmental inconsistencies, and socio-emotional differences.

Learning Disabilities and Arithmetic

There is there is not much empirical data concerning the arithmetic abilities of learning disabled adolescents (Brown, 1975; Cawley, 1978; Johnson, 1979; Marsh et al., 1978). The limited information available describes the student with a learning disability in several general and specific areas (Johnson & Mykelbust; Bartel, 1975; Lerner, 1981). The general areas include the inability to count meaningfully, perform arithmetic operations, understand mathematical signs and symbols, associate numbers with numerals, establish one-to-one relationships and generalize mathematical concepts. Difficulty in telling time, using money, interpreting maps and graphs, understanding when to use a particular process are examples of specific problem areas (Sabatino, Miller, & Schmidt, 1981). These areas often place the learning disabled adolescent two to three years behind his/her expectancy age.

Educators are of the opinion that a complex interaction exists among student, the teacher, and the teaching methods and/or materials and this interaction can facilitate learning and achievement. The instructional methods used with the learning disabled adolescents who have arithmetic deficits must be sensitive and appropriate to their deficits.

Computer Games

General Characteristics

Computer games have a number of characteristics which contribute to their effective use in the classroom. For example, they provide immediate feedback. The students or the players know immediately whether their responses were correct, or incorrect, too late, or too early. They are also provided with feedback regarding the effect of their responses by a constantly updated score on the screen. Players are not provided with reasons that responses were right or wrong, instead, correction and improvement usually occur as a result of a deductive process. As the student or player masters the game, the consequences which contribute to or detract from performance are gradually realized. This information about the nature of a good performance, knowledge of his/her own mistakes, and knowledge of successful results, aid the learning process.

Computer games provide an opportunity for improvement. Typically, computer game players play poorly on the first few games. Rather than regarding their poor performance as failure, the players view the games as a challenge to improve their scores. Improvement seems to result from two factors: familiarity and development of strategy. As they become familiar with the game, they begin to understand the content and sequences, and the consequences associated with the various types of responses. As familiarity grows, the players begin to anticipate events and plan strategies, thus improving the accuracy of their performance. Therefore, computer games provide opportunity for improvement. They allow the student to be "in control" of his/her own learning.

Computer games draw the student's undivided attention. Over a very short time, several responses are not only possible, but are required for good performance. Overt responses (button pushing, etc) often range from ten to thirty to more than a hundred per minute. Covert responses (decisions) occur at the rate of several hundred per minute with the experienced player. Because of their undivided attention, players practice in playing, decision making, strategy planning, and hopefully acquire permanent skills.

Computer games actively involve the player or student. This is important from the educational point of view, as learning is more effective when a learner is actively involved in the learning process.

Computer games provide unlimited repetitive practice and since the computer is emotionless and infinitely patient, this repetition may not be embarrassing or aversive to the learning disabled adolescent. This is particularly important for slow-learning students or special education students who do not often experience success in the classroom.

Computer games provide intrinsic motivation, which is important for learning (Malone, 1981). This is important from the educational point of view as learning is more effective when reinforcement comes from within the person rather than from the outside world.

Malone (1981) conducted a series of research studies on the motivational aspects of computer games. He generated a theory of instruction based on their intrinsically motivating elements in which learning comes from within the person rather than from the outside world. Malone (1980) states that there are three major ingredients inherent in the student-computer game experience which make the games such ideal vehicles for learning. These three ingredients are challenge, fantasy, and curiosity. Challenge is achieved in computer games because levels of difficulty shift in accordance with how well the player is doing. Difficulty depends on such factors as the amount of time needed to reach the goal, the memory capacity required, and the response speed that is required. Thus, these instructional games can vary in difficulty level so that they remain forever challenging. Fantasies abound in computer games. They may be created by the plot, the graphics, and the sound effects. Fantasies are instructionally useful since they help the learner apply knowledge to new concepts. They also provide vivid images related to the material to be learned, resulting in an ideal learning situation, since many psychological experiments have demonstrated that using imagery is one of the best ways to learn new material (Paivio, 1971). Fantasies serve emotional functions, one of which is wish fulfillment. They also can be powerful ways of harnessing pre-existing emotional motivations and can be used to increase interest in learning. The learning environment also is enhanced by evocation of curiosity. To achieve this, one needs to provide an optimal level of informational complexity. By optimal level, Malone (1980) means that the environment should be neither too complicated nor too simple for the learner. The world of learning should be novel and surprising; at the same time, it cannot be incomprehensible. It is possible for the student to select his/her optimal level of complexity by means of speed controls etc.

Computer games provide individualization, an essential ingredient in special education. Individualization is evidenced in two aspects of the game activity. First the student is actively involved in a game, and second, the teacher is then able to give individual attention to other students (Clark, 1978).

Computer games give immediate reinforcement for correct answers, which tends to motivate students. Playing the games requires a combination of speed and accuracy. In learning, speed or frequency of performance is as essential as the accuracy of the performance (Whitle & Haring, 1976; Harghton, 1972). Usually, students advance to the next level on the basis of performance which may be accurate, but may also be slow. Hence, the degree of mastery necessary to retain a skill, to perform it with confidence, and to use it to build more complex skills, is seldom achieved. Since use of computer games provides incentive for fast responses, playing the games results in an increase in speed as well as accuracy.

Finally, what makes computer games so intrinsically rewarding? Csikzentmihaly and Larson (1980) suggest that this results from "A flow of state" in which individuals experience a peculiar, dynamic balanced state of interaction.

> Flow is described as a condition in which one concentrates on the task at hand to the exclusion of other internal or external stimuli. Action and awareness merge, so that one simply does what is to be done without a critical, dualistic perspective on one's actions. Goals tend to be clear, means are coordinated to the goals, and feedback to one's performance is immediate and unambiguous. In such a situation, a person has a strong feeling of control--or personal causation--yet, paradoxically, ego involve-involvement is low or nonexistent, so that one experiences a sense of transcendence of self,sometimes a feeling of union with the environment. The passage of time appears to be distorted; some events seem to take a disproportionately long time, but, in general, hours seem to pass by in minutes.

From this perspective, addiction to computer games can be explained as an action system in which skills and challenges are progressively balanced, goals are clear, feedback is immediate and unambiguous, and relevant stimuli can be differentiated from irrelevant stimuli. This combination contributes to the sense of flow and interaction which make the experience deeply satisfying.

Use of Computer Games in Regular Classrooms

People of all ages have succumbed to the lure of computer games. School age youth struggle to explain the enjoyment which players derive from computer games. Teachers wonder aloud if perhaps the magic of "Pac-Man" cannot be bottled and utilized in the classroom to enhance the student experience. Pointedly, educators are questioning what implications, if any, computer games have for restructuring classroom activities to create a productive learning environment.

At the same time, mathematics educators are increasingly concerned with the attitudes of children and youth toward mathematics and with the general problem of motivation. According to John Biggs (1963), "anxiety appears to be more easily aroused in learning mathematics than it is in other subjects". In recent years, the instructional possibilities of games have come to be recognized.

Games are not only fun, but they are "tremendously useful devices for developing skill in mathematics. Practice in computational skills is just as effective and much more palatable when disguised as a game. Games focus on interest, and one advantage of using games for instruction is that they improve attention/attendance behavior" (Biggs & MacLean, 1969). Kennedy and Michon (1973) note that games can be used in the development of concepts as well as mastery of skills. Games provide needed structure and individualized instruction. They are also valued by mathematics teachers for their variety and novelty. Kennedy and Michon (1973) summarize the advantages of games:

> Games help teachers overcome problems connected with children's mathematics. They give children variety in the way they deal with a topic, allow them to actively participate in the learning process, provide repeated exposures without becoming tiresome and enrich children's background.

Ashlock (1972) notes two characteristics of games which make them useful for helping children master the basic facts of arithmetic. First, because a child does not have to win a game every time, he/she feels more free to be wrong; whereas, it is the ultimate expectation of much conventional instruction that the child will get the correct answer every time. Secondly, if the child is to master the basic facts of arithmetic, he/she must practice "pulling them out of the head" instead of always figuring them out the long way. A game provides the prompting necessary to respond quickly if recall is to be reinforced.

B. David Brooks (1983), a consultant and instructor at the University of Southern California, studied 1000 adolescents who frequented arcade games. Sixty-eight percent had C averages or better, and eighty percent spent less than

$5 a week on games. Only six percent claimed that the games encouraged truancy; ninety percent said they had never seen alcohol or drugs in arcades. Brooks (1983) asserts that games actually promote socialization among peers and between fathers and children. He also found, in a separate study of gang members, that games reduced peer tension by 400 percent. This is corroborated by Antonia Stone (1983), the executive director of New York City's Playing to Win, an organization that has used computer games with incarcerated juvenile offenders. Stone (1983) reported that members of rival gangs overcame their differences to help each other beat their computer opponents in an electronic version of the game Othello.

Patricia Greenfield (1983), a professor of psychology at UCLA who studied cognitive skills required in video games, debunks the idea that they merely foster eye-hand coordination. "According to modern child psychologist Jean Piaget, sensory motor skills are the foundation of abstraction," says Greenfield (1983), and she suggests that games also teach children many cognitive skills and multilevel (rather than linear) thinking, the foundation for mathematical concepts like calculus and the rudiments of physics. "Having to induce the rules makes Pac-Man more lifelike than chess," Greenfield observes. A good games player becomes "very skilled with parallel processing of multiple variables; that's life. Most people who criticize the games can't play them."

Psychologist Lepper (1982) points out that video games could potentially be used to provide an intuitive understanding of many principles of physics. He calls such games "educational simulations" in reference to the fact that physical events can be simulated on the screen by inserting the appropriate laws into the computer program.

W. J. Lynch's study (1981) involved twenty-five learning disabled children between the ages of six and thirteen. Subjects were tested both before and after concentrated playing of a number of video games. The game sessions lasted approximately thirty minutes and were carried out at weekly intervals for twelve weeks. Dramatic improvements occurred. Specifically, children improved in their ability to perform a line-tracing task that tapped into motor ability and in a task of spatial visualization in which they had to match a missing block with a like-shaped contour. Further research is underway to answer such questions such as whether it is best for the children to engage in "structured" or in "free" video game training (W. J. Lynch, 1981).

Most educators agree that classrooms need to be created that motivate and challenge students to succeed in tasks and make it clear that those tasks are worthwhile and relevant (Verble, 1980). It has been argued that the "genius of good teaching is helping the student discover needs he never knew he had" (Combs, 1976). Few educators would quarrel with the notion that the instructors should be sensitive to the needs to create potentially matched challenges and skills (Trump & Vars, 1976).

Computer games in the classroom with characteristics of fun, challenge matched to skill ability, high response rate, feedback and intrinsic motivational appeal may have relevance to the education of adolescents.

In conclusion, the use of computer games in special education classrooms is very limited. Used carefully with a sense of their characteristics, the computer games can have substantial impact on instructional practices in the special education classroom. They can help many students, especially those who have considerable difficulty in school.

Specific Benefits of Computer games for Learning Disabled Adolescents

Learning disabled adolescents do not learn as readily as others of the same chronological age. They lack the ability to master abstract ideas, and are usually unable to learn material without specific instruction. As a result, educational material should be programmed in sequence and presented in such a way that the student will learn at a rate compatible with his/her development.

To implement systematic instruction, it is necessary to apply learning principles and techniques that will facilitate learning. Computer games are based on some of the learning principles that educators believe will facilitate learning for learning disabled adolescents.

1. Computer games provide immediate feedback.
2. Computer games provide immediate reinforcement for correct responses.
3. Computer games proceed in a systematic way. The software is programmed in such a way that the lessons proceed in a step-by-step fashion so that the more basic and necessary knowledge and habits precede more difficult material.
4. Computer games provide repetition of experience sufficient to develop over-learning.
5. Computer games motivate the student toward greater effort due to
   (a) reinforcement and the satisfaction of succeeding,
   (b) sessions of optimal length, and (c) variations in the material presented.
6. Computer games provide success experiences thus increasing self-concept and self-confidence in the learning disabled adolescent.
7. Computer games provide a challenging level of

difficulty which is subtle and inviting. Just as the student accomplishes one goal or level another more difficult level is introduced. Because of previous success, instead of being frustrated, discouraged or disillusioned with the game, the student continues to play to improve skills. As a result his/her coordination and or response times increase and and once again he/she experiences success in learning.

8. Some software packages space or distribute repetitions of material over time. This software repeats the presentation of one concept in many new settings, so that the student returns to it again and again--not as drill but as transfer to a new situation.
9. Computer games provide opportunity to build and consolidate skills in natural settings, an alternative to the more artificial contexts of academic lesson and physical therapy.

Multiple Baseline Designs

In applied behavior research, multiple baseline research designs have recently come to the fore. Baer, Wolf & Risley (1968) call these designs scientific verification procedures, because they allow verification of whether a research procedure is really responsible for a change in behavior. Multiple baseline designs demonstrate causal relationships, and can be applied to single subjects or to single groups. They are frequently used in cases in which reversal of behavior is impossible or undesirable.

In the multiple baseline design, inferences are based on examination of performance across several baselines. This procedure requires that baseline data be obtained concurrently for several behaviors of one subject or one group, or for the same behavior of a subject or group under various stimulus conditions. When all baseline data exhibit acceptable stability in level and trend, an intervention (educational or therapeutic) is applied to the first baseline (one of the behaviors, or conditions, or subjects). During intervention, data continues to be gathered for the remaining behaviors. Only when an appropriate change occurs in the first behavior (or condition, or subject), may intervention be applied to the second. As before, the same abrupt, appropriate change in the second behavior should be demonstrated, while baseline data continue to be gathered on the remaining behaviors. The process is repeated for the third behavior and for all the remaining behaviors.

The unique feature of multiple baseline designs is the demonstration of experimental control. The different behaviors (conditions or subjects) in the design provide a basis for estimating what changes can be expected to occur without the application of intervention. At the time when intervention is applied to one behavior (condition or subject), a comparison exists between intervention and non-intervention conditions. The behavior (condition or subject) that receives intervention should change (i.e., show clear departure from the level of performance predicted by the baseline). It is important to examine whether other baselines that will later receive intervention show any changes or variability during the same period. This comparison of performance across behaviors (conditions or subjects) at the same point in time is an essential aspect of the multiple baseline design.

The three variations of the multiple baseline design are:

1. Across several different behaviors of an subject or group (Kirby, Holborn & Bushby, 1981).
2. Across several different stimulus conditions to which the same behavior of an subject or group is exhibited (Lutzker, 1978).
3. Across several subjects or groups displaying the same behavior under the same stimulus conditions (Gruber, Reeser & Reid, 1979).

Advantages of Multiple Baseline Designs

The multiple baseline design offers several practical advantages. They are as follows:

1. It is a particularly useful design for classroom use for it establishes a functional relationship without withdrawing the intervention, as is necessary in a reversal design.
2. Intervention is not withheld or reversed to demonstrate experimental control (Baer, Wolf, & Risley, 1968; Kazdin & Kopel, 1975; Kratochwill, 1979).
3. It fosters simultaneous measurement of several concurrent target behaviors. Monitoring of concurrent behavior allows for a closer approximation to naturalistic conditions where a variety of responses are occurring at the same time. Second, examination of concurrent behaviors leads to an analysis of covariation among the targeted behaviors.
4. The design eliminates many practical and ethical questions because reversal is not required.
5. Experimental control can be demonstrated without a return to the baseline condition.

6. It allows for evaluation of programs that are designed to teach skills that are irreversible.

Problems in the design

Sometimes the baselines that have not yet received intervention show slight variations. When only the treated behavior (condition or subject) changes, this suggests that normal variability in performance would not account for the change. However, repeated demonstration of changes in specific behaviors (conditions or subjects) when the intervention is applied provides a convincing demonstration that the intervention was responsible.

Concurrent measurement of several baselines is a requirement of multiple baseline design. This requirement can be limiting because it is difficult to identify the requisite number of baseline measures and also concurrent measurements of several behaviors may prove time-consuming, expensive, or otherwise impractical (Horner & Baer, 1978; Scott & Goetz, 1980).

A behavior change may said to have generality if it endures over time. In multiple baseline designs research, Sidman (1960) notes that the key to achievement of generality is in replication of the results. Replication will determine the extent to which results obtained in one study can be generalized across a variety of behaviors.

Inconsistency in the effects of intervention is another problem in multiple baseline designs. This inconsistency is demonstrated in cases in which some behaviors are altered when the intervention is introduced and others are not (Kazdin, 1982). In cases which include only two behaviors and only one of these behaviors changes at time of intervention, the results are ambiguous since factors other than intervention may well have caused the behavior change (Kazdin, 1980). Thus, it is good strategy to incorporate several behaviors (or conditions, or subjects) in the design, since the effects of intervention will be clear from the several behaviors that do change when the intervention is introduced.

Use of multiple baseline designs in research gives rise to additional problems. Since intervention must occur in an orderly fashion, a particular behavior may be allowed to continue over a prolonged period of time until its proper time for intervention has arrived. This prolongation of destructive or disturbing behavior may be undesirable from clinical or ethical viewpoints. It is also possible that an extended baseline will introduce ambiguity or may result in boredom, fatigue and competitive responding by learners. Also, prolonging baseline measurers may be considered ethically questionable when intervention is postponed on behaviors that require immediate action (e.g., physical aggression direction against self or others) (Kratochwill, 1978; Strain & Shores, 1979; Sulzar-Azaroff & Mayer, 1977).

These problems may be avoided, however, by using short baselines or brief lags before applying intervention to the next baseline. Also, intervention may be applied to two or more behaviors at once, resulting in shorter baselines.

Multiple Baseline design across subjects

Multiple baseline design across subjects is one of three variations of multiple baseline design. In this design, the investigator sequentially applies intervention to the behavior of several subjects who exhibit the same behavior under similar environmental conditions. The first step after selection of subjects is to gather baseline data regarding a particular behavior of a subject. The number of subjects whose behaviors are observed or measured determines the number of baselines, (i.e., multiple baselines). Measurement of baseline performance of the target behavior of each subject continues until a stable trend and level is established for each. The investigator proceeds by applying the intervention to the first subject's behavior while baseline measurements are continued for the other(s). The behavior of the subject exposed to the intervention is expected to change; the behaviors of others are expected to continue at their baseline levels. When the target behavior of the first subject reaches the expected level, the intervention is extended to the second subject's behavior. This sequential and systematic procedure of implementation of intervention is continued until all of the subjects for whom baseline data were collected have received the intervention. At all times, the effect of the intervention is demonstrated when a change in performance is obtained at the point when the intervention is introduced and not before.

Figure 2.1 shows a sequential administration of an after-school tutoring contingency on three tenth-grade students who were obtaining grades of D and F on quizzes given three to four times a week in their French class. During baseline, quizzes given throughout the week were scored independently by the teacher and an outstanding student. Starting on Day 10, Dave began receiving after school tutoring whenever he obtained D or F grades on a quiz. Baseline conditions were maintained for Ray and Debbie. On Day 15, Ray began his after-school contingency, whereas Debbie's tutoring contingency began on Day 20. The results show that grades improved after each student was exposed to the after-school contingency.

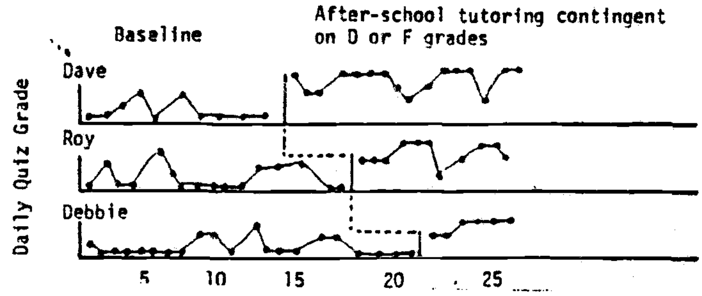

Figure 2.1 A record of quiz score grades for three high school French class students. Baseline--before experimental procedures. After-school tutoring contingent on D or F grades. Pupils required to stay after school for tutoring if they score D or F on daily quizzes (Hall, R. V., Cristler, C., Cranston, S. S., & Tucker, B., 1970).

The multiple baseline design across subjects is advantageous for classroom use for several reasons. First, the design targets a common skill across several learners. Secondly, it staggers instruction to allow for rate differences. Thirdly, it permits teachers to validate program effectiveness across several students, thus increasing the generality of the findings (Cuvo, 1979).

Problems in the multiple baseline across subjects design

The investigator using the multiple baseline design across subjects faces the problems of covariation among baselines, inconsistent effects of the intervention, prolonged baseline, lack of random sampling, and demonstration of experimental control.

In the multiple-baseline design across subjects, it is possible that altering the behavior of one subject influences the behaviors of other subjects, thus causing covariation across baselines. Covariation is also caused when baselines are interdependent so that the implementation of intervention to one baseline leads to changes in other baselines even though these baselines have not received intervention. Intervention based on reinforcement or punishment has occasionally produced such effects, i.e., behavior changes among subjects who have merely observed positive or negative reinforcement of the behavior of others (Kazdin, 1982). It is also possible that extraneous events may coincide with the application of intervention and thus lead to changes in baselines. This ambiguity may be erased by applying rapid intervention effects to those baselines that show the covariance effects (Kazdin, 1983).

Another problem of this design occurs when the intervention may produce inconsistent effects on the subjects to which it is introduced. Inclusion of several subjects in the design will overcome this problem since clear effects may be observed in the several subjects that do show a change when the intervention is introduced.

The third problem that may occur with use of this design results from withholding intervention for a prolonged period of time while the investigator is waiting to apply the intervention to the final subject. As mentioned above, clinical and ethical considerations make it difficult to justify withholding intervention for a long time. Also a prolonged or extended baseline may introduce ambiguity into the design. In cases where subjects are retested on several occasions, extended baseline assessment may lead to positive or negative changes in behavior that seem to have no explanation. These problems can be avoided, however, by utilizing short baseline phases or by measuring baselines on an intermittent rather than on a continuous basis (Horner & Baer, 1978).

A fourth criticism of this design might be that it does not employ random sampling in selection of subjects. However, random sampling is not essential. As pointed out by Edgar & Billingsley (1974), most psychological and educational research does not provide true random samples. They state:

> In the absence of random samples, hypotheses still be tested, but statements of significance are limited to the effect of the treatment of Ss actually utilized generalizations being based on logical considerations of nonstatistical nature (Edington, 1967). This logical rather than statistical basis for generalization is applied in most large sample studies and is equally applicable when N=1 whether tests of significance applied to the data obtained from the reversal or multiple baseline investigation. In many cases generalization may, in fact, be more readily made from N=1 studies due to the opportunity for more accurate delineation and precise control of Ss characteristics.

The potential drawback, that of not using a random sample, may be overcome by making detailed statements of the characteristics of the subjects and detailed descriptions of situational characteristics (Edgar & Billingsley, 1974).

A final problem is in the demonstration of enough experimental control for believability (Baer et al., 1968). In this design, experimental control is demonstrated by collecting baseline data of the same behavior for each Subject. After behavior of each Subject has reached a stable state, the intervention is applied to only one of them while baseline conditions are continued for others. The behavior of the person exposed to the intervention is expected to change, while the behaviors of the others would be expected to continue at their baseline levels. When the target behavior of the first Subject reaches the expected level, the intervention is extended to the second Subject. This procedure is continued until all the subjects for whom baseline data were collected receive the intervention. Experimental control is demonstrated only when behavior of each subject changes maximally only upon application of the experimental variable.

Illustration of the multiple baseline design across subjects

Montague (1984) investigated the effects of use of an eight-step cognitive strategy on the ability of six learning disabled adolescents to solve verbal math problems. The eight-step strategy was designed to enable students to read, understand, carry out, and check verbal math problems that are customarily encountered in the general math curriculum at the secondary level. During the intervention phase, students received strategy acquisition training over three sessions. When they demonstrated that they had memorized the eight strategy steps, they practiced applying this strategy, and testing commenced. Utilization of the strategy and improved performance were measured by resulting test scores. (The number of correct responses and the number of minutes taken to finish the test.)

The data indicated that this eight-step cognitive strategy was an effective intervention for this sample of students who had deficits in verbal math problems.

All the students demonstrated improved performance (correct responses) on two-step verbal math problems. Four of them generalized the use of the strategy to three-step problems. Four students maintained improved performance over two weeks with no instruction or practice. Substantial increases were noted in the amount of time required to complete these problems. These tests were administered immediately after strategy acquisition training.

Appropriateness of use of multiple baseline design across subjects in the present study

Use of multiple baseline design across subjects is appropriate for the present study because:

1. The study is an experimental analysis of individual behavior.
2. The population is small.
3. There is no random sampling.
4. All subjects are exposed to the same environmental conditions.
5. All subjects have the same target behavior (arithmetic deficiency) and are of similar age (i.e., between 16 and 18 years).
6. Continuous or repeated measurement of each subject's behavior will be employed. Behavior varies in frequency as a function of normally occurring events, and repeated measurement of the behavior of a subject is thought to be equivalent to determining test-retest reliability of a measurement with many subjects.
7. Evaluation of data occurs through visual inspection rather than by statistic analysis.

Visual inspection of data is a crucial characteristic of this methodology (Baer, 1977).

8. Continuous measurement over time allows the investigator to see changes in the data as a function of stable patterns of performance within different conditions.
9. Experimental control is demonstrated by simultaneous measurement of several concurrent target behaviors.

Multiple baseline designs demonstrate that a particular intervention has produced an effect by showing that at different times behavior change occurs if, and only if, the intervention is present. These designs require no reversal conditions in order to demonstrate the efficacy of the intervention. Instead, data are collected across behaviors, settings, or subjects and experimental control is demonstrated when behavior is altered as a function of exposure to the intervention. There are problems inherent in multiple baseline designs that can be avoided if the investigator is aware of them.

In multiple baseline design across subjects, the intervention is applied, in sequence, to a particular behavior of matched subjects exposed to similar environmental situations. Problems resulting from covariation, inconsistencies of intervention, prolonged baseline, and small samples do occur. However, recommendations of Kazdin, 1982; Sulzer-Azaroff & Mayer, 1977; Hersen & Barlow, 1978; and Edgar & Billingsley, 1974, can be used to resolve or avoid the possibility of ambiguous results.

Summary

The field of learning disabilities has been developed as a specialized field by Kirk (1963, 1972) and since then, many important people have contributed to it. A learning disabled adolescent exhibits certain characteristics or behaviors such as low achievement, hyperactivity, and others. Identification of these characteristics enable the educator or teacher to take steps towards remediation. Although extensive work has been done in areas of reading and language with these students, little has been done in the area of arithmetic skills. Therefore, a need for research exists.

Intervention techniques used with the learning disabled adolescent must take into consideration not only general problems (i.e. perceptual disorders) but also low achievement in arithmetic. Activities in the classroom should provide motivation, active participation, immediate feedback, and repetition. Computer games provide these and should be considered as a viable instructional strategy.

Multiple baseline designs are used in applied behavioral settings. They are popular because they do not require reversals of performance. In multiple baseline design across subjects, one variation of multiple baseline design, the effects of an intervention with each of the subjects are clearly demonstrated because the intervention has been presented to each subject at different points in time. Problems in this design can be avoided if the investigator is aware of them.

III. Methodology

This chapter will discuss the subjects, settings materials, experimental design and research procedures.

Subjects

Two female and two male learning disabled adolescents, enrolled in special education mathematics classes at South Albany High School, Albany, Oregon, participated in this study. All had been diagnosed as learning disabled by the school psychologist. (The criteria used to determine specific learning disabilities are listed in Appendix C.) These subjects were selected for this study because they had deficiencies in the knowledge of multiplication and division facts.

Subject A

At the time of the study, Subject A was sixteen years old, the oldest of three children. Her sister was a year younger, and a half brother was five years old. Subject A lived with her mother and stepfather, a construction worker. Her natural father lived in California.

Subject A was born with a cleft palate and has had chronic eustachian tube dysfunctions with recurrent middle ear infections. Her cleft palate has been repaired. She has a hearing aide for hearing loss. She was seen biannually by a representative of the Crippled Children's Division.

She had participated in speech therapy and special programs since entering public schools. Her speech was nasal because of the palate. She demonstrated poor knowledge of general information, probably as a result of her hearing loss.

Subject A was working toward a standard high school diploma. She received one period of resource assistance for help with her mainstream classes. She received individualized instruction in mathematics and language arts.

Subject A was well motivated in her classes. She was pleasant and positive. She participated in a counselling group to develop social skills and improve her self-concept.

During the baseline phase and at the beginning of the intervention phase, she worked the multiplication and division problems by counting on her fingers. She used a variety of finger-counting techniques such as tapping her fingers on the table, on a chair, or on her cheek. During the first session with the computer, she asked many questions about the procedure and had a great deal of difficulty comprehending the task. She needed reassurance that she was proceeding in the expected way. She improved in every succeeding session, showed increased confidence, and exhibited enthusiasm.

Subject A´s IQ was borderline (70-79) in the verbal area and low normal in the performance area. The verbal score was attributed to the hearing loss.

Subject A's scores on the Peabody Individual Achievement test revealed the following grade levels: mathematics, 4.4; reading record 7.0; reading comprehension, 6.8; spelling, 4.2; key math, 4.2.

Subject B

Subject B was a sixteen-year-old hyperactive male, the youngest of four children. He had two older sisters and one older brother. Both the sisters and the brother had similar learning problems. Subject B's mother and father were separated. Subject B's father lived in the state of Washington, along with the brother, who lived there because of delinquency problems he experienced while living with the mother. The older sister was married. Subject B lived with his mother and stepfather. This was subject B's mother´s third marriage. She was a housewife.

Subject B had been in special programs since first grade when he had trouble paying attention. He was placed in kindergarten for one-half of the year and in first grade for the second half of the year. He was returned to first grade the following year. He also repeated third grade.

Throughout his schooling, Subject B received special help in reading, spelling, and math. His family valued education. His mother always came to the conferences at school and was very supportive of the school. Subject B worked to the best of his ability to earn C´s and D's in his mainstream classes.

Subject B was well within the normal range (90-109) in vocabulary, comprehension, and general information. His weaknesses were in auditory attention span and mathematics. He was small for his age and immature in development.

Subject B enjoyed playing the computer games. He required minimum training on the computer, and was very vocal and excited during the training sessions. As the training and intervention sessions started, he waited everyday at 8:20 a. m. for the investigator to open the resource room door. He was bored during drill activities and showed his boredom in various ways, such as playing with a pencil on the table, and asking irrelevant questions.

Subject B's scores on Woodcock tests revealed the following grade levels: word identification, 1.9; word comprehension, 2.5; and passage comprehension, 2.6.

Scores on key math revealed 5.3 grade level.

Scores on Peabody Individual Achievement Test revealed the following grade levels: mathematics, 4.4; reading record. 3.1; reading comprehension. 2.7; spelling, 2.8. Scores of written spelling revealed the following: predictable words, 2.4; unpredictable words, 2.4; total, 2.4.

Subject C

Subject C was an eighteen-year-old female who lived with her mother in Albany. The mother received disability aid for a bad back and aid to dependent children for Subject C. Subject C was the only child.

Subject C´s mother did not value education. She rarely attended a conference unless the school threatened to remove Subject C from school and call welfare. She also had a drinking problem. Subject C had extreme school attendance problems.

Subject C's mother was separated from her father, who lived in Salem. She had been married a second time, but was divorced from her second husband.

Subject C repeated kindergarten twice before entering first grade. She was in special, self-contained classes until third grade, when she was mainstreamed. From third grade on, Subject C attended regular classrooms with assistance from special programs for certain subjects.

Subject C will earn a certificate of completion from high school, rather than a standard diploma. At the time of this study, she was in a program aimed at independent living and work experience.

Subject C´s IQ was in the borderline (70-79) area. Her strengths were in visual memory and visual closure. Her weaknesses were in general information and vocabulary.

During the baseline and intervention phases, she counted on her fingers and preferred to guess. During training sessions she was reluctant to play, as the speed of the game seemed to frighten her. She improved in every succeeding session but maintained speed 2 for all games.

Subject C's scores on Woodcock tests revealed the following grade levels: passage comprehension, 6.0; word identification, 6.0.

Scores on written spelling test revealed the following grade levels: predictable words, 3.0; unpredictable words, 3.9; total 4.1.

Scores on written English revealed the following grade levels: capitalization, 3.0; punctuation, 2.0; written expression, 5.0.

Scores on Peabody Individual Achievement Test on mathematics revealed 6.0 grade level.

Subject D

Subject D was a sixteen-year-old male. He was confined to a wheelchair, as a result of an automobile accident which had occurred when he was three years old. He lived in a sheltered environment from the time of this accident until age eight. The main emphasis of his schooling had been on physical therapy with limited academics.

Subject D entered the public school at age nine (when he was returned to his mother). He was placed in the second grade.

Subject D was the youngest of three boys. He lived with his mother and brother in an apartment in Albany. The mother was unemployed; their income came from child support and welfare.

Subject D is working toward a certificate of completion rather than a diploma. His programs included survival skills and work experience. He attended three special classes and two mainstream classes. He had been in special classes since his accident at age three.

Subject D was motivated to do well in school. He earned a C in classes at his ability level, but he had a tendency to quit if he perceived things to be too difficult.

Subject D's IQ was in the low normal range (80-89). An accurate IQ had not been assessed due to disability.

During the baseline sessions he needed lot of prodding and sometimes gave up easily. He tended to be erratic, and impulsive and constantly sought the investigator's approval and encouragement. He had no physical difficulty in working with the computer and every day he looked forward to playing the computer games.

Subject D's scores on Peabody Individual Achievement Test revealed the following grade levels: mathematics, 2.6; reading record, 3.6; reading comprehension, 3.6; spelling, 2.8; and key math, 3.1.

The Setting

The sessions dealing with baseline, training, and the intervention sessions were conducted each morning between 8:20 and 9:20 a.m. in a resource room across the hall from the regular classroom. Each subject attended separately and received all the investigator's attention. An Apple IIe computer was placed at the northwest side of the room. Generally, the resource room was used by the students and the faculty members for preparation, testing, and for receiving visitors. Since the room received the least use during 8:20-9:20 a.m., it was quiet and appropriate for conducting the experimental sessions. The room was well lighted and carpeted. A resource teacher or a faculty member was always present in this room but did not participate in this study.

Materials

Two math games, Meteor Multiplication and Demolition Division (DLM, 1982), were used in the training and in the intervention phases. Meteor Multiplication presented multiplication problems using numbers 0 through 9 and Demolition Division presented division problems using the numbers 0 through 9. (For a description of these games see Appendix D.) These games were chosen by the investigator for the following reasons:

1. The games had video arcade game format.
2. The games dealt with basic multiplication and division facts.
3. Directions for the games were in simple English.
4. The content level of the two games (Meteor Multiplication and Demolition Division) which ranged from 0 to 9 was appropriate for the four learning disabled adolescents.
5. The games allowed the student to determine the speed range and content level.
6. There were ten problems in each game (or presentation).
7. After each game, there was feedback of the number

of correct and incorrect responses.

8. The games fostered independent learning.
9. The games provided attention, motivation, retention and transfer which, according to Gagne & Briggs (1979), are some of the "external events of instruction" which facilitate new learning.

In addition to these computer games, drill activities in multiplication and division facts using numbers 0 through 9 were used during the baseline phase (See Appendix E for an example worksheet). The problems for drill activities were randomly selected from special education class textbooks and student workbooks.

Investigator-made pre- and post-tests (See Appendix F) were administered before and after the experiment. The pre- and post-tests were one and the same. The tests developed by the investigator consisted of fifty multiplication fact items and fifty division fact items, which were randomly selected. (See Appendix G for the special program written to randomize multiplication and division fact items for the purpose of investigator-made pre- and post-tests.) from Meteor Multiplication and Demolition Division computer games.

The Experimental Design

Multiple baseline design across subjects, a variation of multiple baseline design (Baer, Wolf & Risley, 1968), was used in this study to demonstrate the effectiveness of the intervention strategy.

The experimental design involved five phases: pre-testing, baseline measurement, training with computer games, intervention, and post-testing.

In the pretest phase, the four learning disabled adolescents were assessed for their basic knowledge of multiplication and division facts using numbers ranging from 0 through 9. After the pretesting, the baseline data were collected simultaneously for each subject. Once a stable baseline was achieved on the first subject (or any one of the four subjects), training with the computer games was initiated for that subject. During training sessions, the subject was taught to use the computer and to play the computer games, Meteor Multiplication and Demolition Divisionwith the help of the games manual (see Appendix H). As soon as the subject was able to play the games by himself/herself without the investigator's help, intervention (treatment) was applied. During the training and intervention phases for a given subject, baseline data collection continued for the remaining subjects. Training with the computer games and intervention for the next subject began when he/she had reached stability in the baseline phase. This procedure was continued in sequence until the intervention was applied to all the subjects under study. In every case, the training and intervention was not applied until baseline stability had been achieved. (For a detailed description of the multiple baseline design across subjects, see Chapter Two). Finally, each subject was post-tested to assess his/her knowledge of basic multiplication and division facts.

In this design, internal validity was determined through the following steps (Baer, Wolf & Risley, 1968; Sidman, 1960):

1. Selection of the four learning disabled adolescents was based on functionally related target behaviors.
2. Target behavior of each subject was measured until a baseline stability was established.
3. Each subject was trained in the use of computer games.
4. As intervention was applied to the behavior of one subject, monitoring the baseline measurements for the other subjects continued until an expected level (due to intervention) was reached.
5. Step 4 was repeated for each subject.

Baer et al. (1968) and Sidman (1960) have stated the above steps as being criteria for determining the internal validity or reliable control.

Procedures

Pretest

An investigator-designed pretest was administered to each of the four learning disabled adolescents (Appendix F). The purpose of the pretest was to determine subjects' knowledge of multiplication and division facts ranging from 0 to 9. The problems for this test were randomly drawn from the content of computer games (Meteor Multiplication and Demolition Division). The content of these games was made up of multiplication and division problems ranging from numbers 0 to 9. The pretest consisted of fifty problems each in multiplication and division facts. The problems were on two different sheets (See Appendix F). The time limit for the pretest was ten minutes--five minutes each for multiplication and division facts.

This informal investigator-designed test was developed for the following reasons:

1. It related to academic concerns in basic multiplication and division facts of the learning disabled adolescent.

2. It blended with the IEP math program in the school.
3. It emphasized precise skills that a learning disabled adolescent must acquire.
4. It allowed data to be collected within the subjects's "natural environment".

Validity of pre- and post-tests was established by content present in the computer games (Meteor Multiplication and Demolition Division). The items for the tests were drawn randomly from the existing population of items of the games. (See Appendix G. Appendix G is a program written by the investigator for this study.) Therefore, the tests have adequate content validity as they were representative samples of the items in the games.

Yesseldyke & Salvia (1974) state that the behaviorist is not faced with demonstrating that his measurement device reliably and validly assesses some hypothetical construct; rather he must only demonstrate that at least two people can agree on the criteria for the occurrence of a behavior. In this study, reliability of the tests was assessed by inter-rater reliability. Two raters, a resource teacher from South Albany High School and a graduate assistant from OSU, along with the investigator rated the pre- and post-tests and worksheets of drill problems. Prior to the beginning of the study, the investigator met the two raters separately to discuss the nature of the experiment and the use of pre- and post-tests and worksheets of drill problems. A manual (see Appendix H) of instructions was given to each. Regular meetings were held by the investigator with the raters separately throughout the course of study to answer questions and clarify procedures. The method used to measure the correct responses in pre- and post-tests and the worksheets was by direct recording of permanent products. Reliability of the data obtained from the pre- and post-tests and worksheets was calculated by dividing the number of correct responses on which the two raters and the investigator agreed by the total number of correct and incorrect responses and multiplying by 100. According to Nunnally (1967) in applied settings where important decisions are made with respect to scores, a reliability of .90 is the minimum that should be tolerated and a reliability of .95 should be considered the desirable standard.

Baseline

Following the pretest, baseline measurements were conducted for each subject. Each was given a worksheet of drill problems, ten problems each in multiplication and division which had been taken randomly from their classroom textbooks and workbooks (See Appendix E). The completed worksheet was scored by the investigator at the end of the period (9:20 a.m.), and the correct and incorrect responses were recorded. During this baseline phase, no instruction was given, although feedback in the form of reassurance or clarification was given if the subject requested it. At the end of the each week, the two raters besides the investigator independently scored all the worksheets.

Training

Individual training began for each subject when his/her baseline stabilized. The length of baseline was different for each subject and was dependent on each subject's individual performance. Each training session began with the investigator seated beside the subject at the table with the Apple IIe. The investigator then trained the subject in the use of the computer and in playing the games (See Appendix H). All correct and incorrect responses, whether or not they were prompted by the investigator, were treated as training trials.

In each session the following specific procedures were followed:

1. Each subject was given an explanation and a demonstration for each game.
2. Each subject was given instructions and allowed to practice with the keyboard.

3. When the subject made a correct response to the problem the investigator responded with either; a) verbal praise ("Well done, Good" etc,); b) repetition of subject's answer; or c) clarified instructions.
4. When the subject made an error or was reluctant to play, the investigator either a) provided the correct responses; b) discussed the subject's reluctance to play; c) provided extra practice on the consistently missed problems; or d) checked to see whether the subject had difficulty with the game controls.
5. Each training session lasted ten minutes.
6. Options in the game were selected according to the player's competency with math facts. If the player knew few math facts he/she was started with numbers 0-3 at a low speed level for two minutes. If a player knew some math facts but was slow and frequently made mistakes he/she was started at the content and speed levels where he/she would experience more incorrect responses than correct responses. This strategy was used on the assumption that improvement occurs when

> there is room to improve and the games provide enough challenge to allow the player to improve in both speed and accuracy.

Training for each subject continued until the subject could play the game without assistance. Training time varied with each subject because length of training phase depended on individual differences. While the training session was conducted with one subject, baseline sessions were continuing for the remaining subjects.

Intervention

As soon as the subject could play the game by himself/herself, training was stopped and intervention was applied. Intervention involved playing computer games without the investigator's assistance. During intervention, the subject played five games each of multiplication (Meteor Multiplication) and division (Demolition Division), each day for ten minutes. The computer recorded the number of correct and incorrect responses. The investigator simul-taneously recorded the correct and incorrect responses as a reliability check to the computer. During intervention, a subject's progress was controlled by the subject himself/herself through two major options. The two options were content level of the problems (using numbers 0-3, 0-6, 0-9) and the speed at which the game was played (1 was the lowest and 9 the fastest).

Post-test

As soon as the intervention phase stabilized for each subject, he/she was tested with the same test used in pre-testing.

Reliability

The data from pre- and post-tests and baseline were recorded for interrater reliability by a research assistant from OSU, a resource teacher from South Albany High School, Albany Oregon and the investigator by permanent product recording method. This measurement of permanent products refers to the measurement of some product following a response (Tawney & Gast, 1984). When teachers grade a spelling test or check arithmetic problems, they are engaged in the measurement of permanent products. Other examples of permanent products are records of expanded complexity of sentence writing (Heward and Eachus, 1979), spelling accuracy (Neef, Iwata, and Page, 1980) and evaluations of the completion of assembly tasks (e. g., puzzles, circuitry boards), and numbers of tasks completed. This type of recording is then translated into some numerical form, usually the number or percent of correct answers. In this study, correct answers to multiplication and division facts were the enduring products. This method has several advantages. They are:

1. It does not require continuous measurement.
2. It is nonintrusive.
3. It yields precise records of subject's behavior which can be stored for later comparison.
4. It permits the objective evaluation by the observer.
5. It is conducive to "seat work".

The reliability coefficient of permanent product data is determined by the following formula:

$$\frac{\text{\# of correct responses}}{\text{\# of correct responses + \# of incorrect responses}} \times 100$$

In addition, reliability, of the results of the experiment was established by replication. Replication is defined by Sidman (1960) as "... repetition of a given experiment by the same experimenter on the same subject." This type of replication increases confidence in the reliability of results and is used in applied research.

Maintenance

To establish whether the higher achievement in multiplication and division facts was maintained in the absence of further playing, a follow-up test was given for each subject exactly thirty days after the end of the intervention. The test was the same used in pre- and post-tests. The test procedure used with subjects was identical to that used in pre- and post-tests.

Organization and analysis of data

Data collected for each subject are graphed (line graph) and judgments are made about whether change has occurred. "Graph is the primary form of data processing, research decisions, judgments and conclusions are based almost exclusively on graphed data" (Parsonson & Baer, 1978). Baer (1977), Micheal (1974), and Sidman (1960) also state that investigators in experimental and applied analysis should seek variables that attain potent effects and that such effects should be obvious from merely inspecting the data. The graphs are analyzed by these criteria:

1. Changes in the mean (average) performance across phases.

2. Changes in the level of performance (shift at the point that the phase is changed).

3. Changes in trend (differences in the direction and rate of change across phases).

4. Rapidity of change at the point that the intervention is introduced.

Visual analysis of graphic data has several advantages for special educators and other service personnel (Tawney & Gast, 1984). They are as follows:

1. Visual analysis approach can be used equally well for the data of individuals or small groups.
2. Visual analysis is a dynamic process in that the data are collected and analyzed continuously.
3. Visual analysis focuses on the analysis of individual data patterns.
4. Visual analysis permits a teacher to make data-based decisions throughout the program.
5. Visual analysis permits a discovery of interesting findings which may not be directly related to the original research problem. Serendipitous findings (Sidman, 1960; Skinner, 1956) are possible because primary data are collected, graphed and analyzed continuously.
6. Graphic presentation of primary data permits independent analysis and interpretation of data, thus permitting others to judge for themselves whether an intervention has merit and whether the findings are reliable and have social validity.
7. By graphing and analyzing the data for all subjects, the effectiveness of an intervention with an individual subject is neither overestimated nor underestimated.

For these reasons the visual analysis of graphic data is the strategy preferred by behavioral researchers working in applied settings (Tawney & Gast, 1984).

IV. RESULTS

This chapter presents the data of the study. Interrater agreement data from the pre-and post-tests and baseline phase are presented first, followed by each subject's individual baseline, intervention, and maintenance data. Finally, the performance of all four subjects is summarized.

Interrater Agreement from the Pre- and Post-tests

Table 4.1 shows interrater agreement between raters for each subject on knowledge of basic multiplication and division facts obtained by the pre- and post-tests. The overall pretest means of interrater agreement for subjects A, B, C, and D were as follows: 98% (range 98%-100%) in multiplication and 99% (range 99%-100%) in division for subject A, 99% (range 99%-100%) in multiplication and 100% (range 100%) in division for subject B, 100% (range 100%) in multiplication and 98% (range 98%-100%) in division for subject C, and 100% (range 100%) in multiplication and 100% (range 100%) in division for subject D. The overall post-test means for rater agreement for subjects A, B, C, and D were as follows: 100% (range 100%) in multiplication and 98% (range 98%-100%) in division for subject A, 98% (range 98%-100%) in multiplication and 100% (range 100%) in division

Table 4.1

Interrater Agreement Between Raters for Each Subject

Subject	Pretest		Post-test	
	Mult Mean(range)	Divis Mean(range)	Mult Mean(range)	Divis Mean(range)
A	98%(98%-100%)	99%(99%-100%)	100%(100%)	98%(98%-100%)
B	99%(99%-100%)	100%(100%)	98%(98%-100%)	100%(100%)
C	100%(100%)	98%(98%-100%)	100%(100%)	100%(100%)
D	100%(100%)	100%(100%)	99%(99%-100%)	100%(100%)

for subject B, 100% (range 100%) in multiplication and division for subject C, and 99% (range 99%-100%) in multiplication and 100% (range 100%) in division for subject D.

Interrater agreement from the baseline data

Table 4.2 shows the interrater agreement between raters for each subject in basic multiplication and division facts during baseline phase. The overall means of rater agreement for Subjects A, B, C, and D were as follows: 95.8% (range 95.6%-96.9%) in multiplication and 100% (range 100%) in division for subject A, 100% (range 100%) in multiplication for subjects B, C and D and 100% (range 100%) in division for subjects B, C and D.

Table 4.2

Interrater agreement between raters for each subject in the baseline phase

Subject	Multiplication		Division	
	Mean	Range	Mean	Range
A	95.8%	94.6% - 96.9%	100%	100%
B	100%	100%	100%	100%
C	100%	100%	100%	100%
D	100%	100%	100%	100%

Table 4.3

Raw Data

Subject	Pretest %Achievement		Posttest %Achievement		Maintenance %Achievement	
	Multn	Divisn	Multn	Divisn	Multn	Divisn
A	72	24	96	62	80	60
B	34	34	92	90	82	60
C	58	20	80	82	78	72
D	38	2	60	40	54	40

Subject A

Baseline

Figures 4.1a, and 4.1b present the number of correct responses of Subject A in multiplication and division facts during the five days of the baseline phase. The graph in Figure 4.1a depicts a stable data path across five data points, and the graph in 4.1b reveals a slight variability. Mean percent of correct responses in multiplication was 60% (range 60%-60%) and in division was 20% (range 10%-30%). Subject A's data showed more deficiency in division than in multiplication.

The raw baseline data for Subject A is presented in Table 4.4. From that table it can be seen that Subject A scored 6 out of 10 multiplication problems correctly for on Days 1, 2, 5, 6 and 7. Her correct responses in division problems were as follows: 1 out of 10 problems on Day 5, 2 out of 10 problems on Days 1, 6 and 7, and 3 out of 10 problems on Day 2.

Subject A

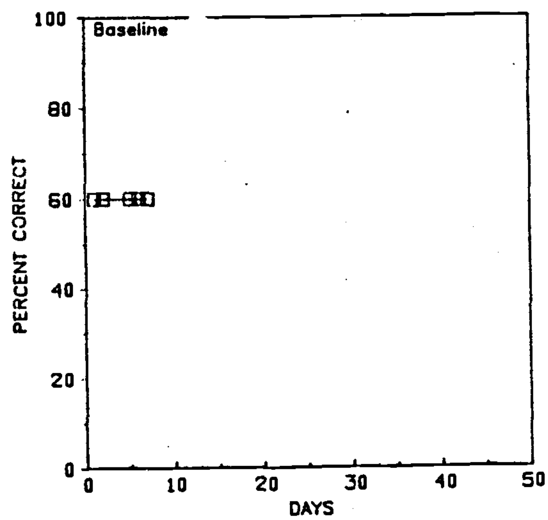

Figure 4.1a The percentage of correct responses Subject A made in multiplication facts during baseline phase.

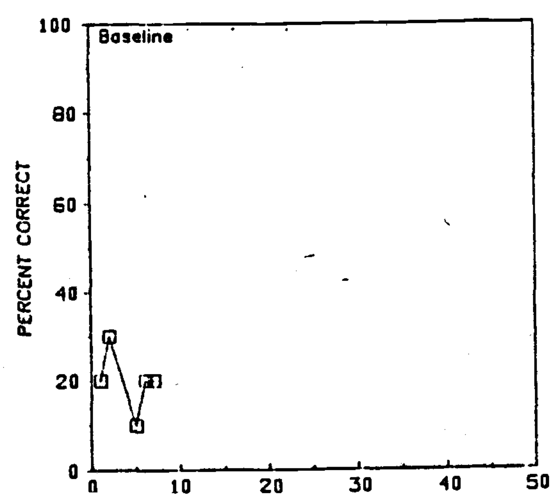

Figure 4.1b The percentage of correct responses Subject A made in division facts during baseline phase.

Table 4.4

Baseline Data for Subject A*

Day	# Correct responses Mult.	# Correct responses Divn.	# incorrect responses Mult.	# incorrect responses Divn.
1	6	2	4	8
2	6	3	4	7
5	6	1	4	9
6	6	2	4	8
7	6	2	4	8

* 10 problems each in multiplication and division facts

Training

Subject A required twelve ten-minute-long training sessions, one each day. She was slow, reluctant, seemed threatened at the beginning, and took a longer time to train. Training was stopped when the subject was able to play the the games by herself without the investigator's help.

Intervention

The graphs in Figures 4.1c and 4.1d show that frequency of correct responses gradually increased across time in both multiplication and division during intervention phase for Subject A. Graph 4.1c shows a data path that was initially stable but increased across time. Graph 4.1d shows that the number of correct responses increased on the first three days of the intervention phase; however the trend began to reverse on the fourth day and continued to increase on the following four days. There was a 25% overlap in the number of correct responses in multiplication between baseline and intervention phases, with the level stabilizing at 80% or below per day, beginning on Day 29 during intervention. Mean percent of correct responses in multiplication was 76.25% (range 60%-84%) and 66.75% in division (range 58%-76%).

Intervention

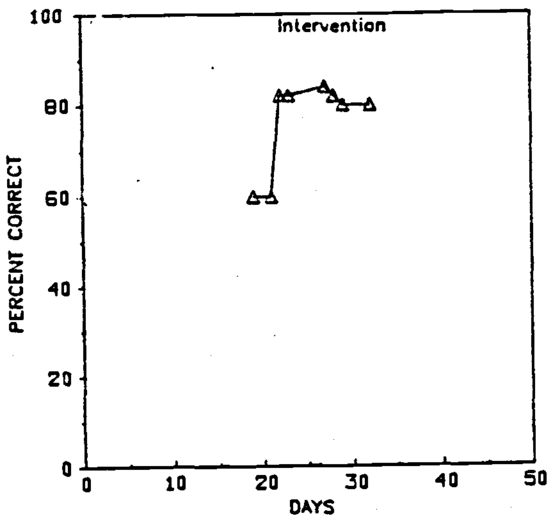

Figure 4.1b The percentage of correct responses Subject A made in multiplication facts during intervention phase.

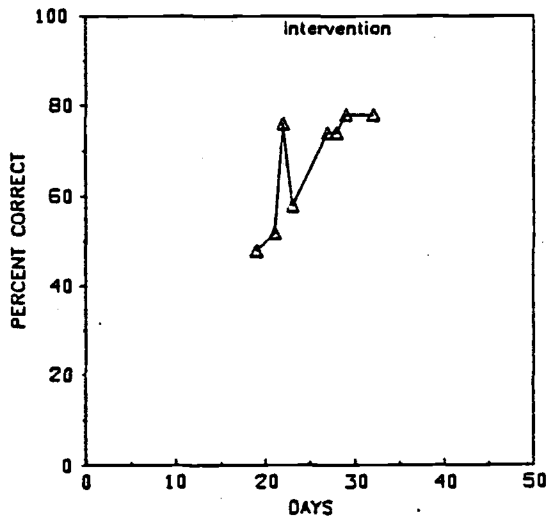

Figure 4.1d The percentage of correct responses Subject A made in division facts during intervention phase.

The raw intervention data for Subject A is presented in Table 4.5. From that table it can be seen that the correct responses of Subject A in multiplication problems were as follows: 30 out of 50 problems on Days 19 and 21, 40 out of 50 problems on Days 29 and 32, 41 out of 50 problems on Days 22, 23 and 28, and 42 out of 50 problems on Day 27. Her correct responses in division problems were as follows: 24 out of 50 problems on Day 19, 26 out of 50 problems on Days 23, 37 out of 50 problems on 27 and 28 and 38 out of 50 problems on Days 29 and 32.

Maintenance

Follow up assessment for Subject A was conducted exactly thirty days after the termination of intervention. The percentage of scores in multiplication and division were 80% and 60%, respectively. The raw data for maintenance is presented in Table 4.3. The scores in multiplication and division were well above the pre-test scores and little below the post-test scores.

Table 4.5

Intervention Data for Subject A*

Day	# correct responses Mult.	# correct responses Divn.	# incorrect responses Mult.	# incorrect responses Divn.
19	30	24	20	26
21	30	26	20	24
22	41	38	9	12
23	41	29	9	21
27	42	37	8	13
28	41	37	9	13
29	40	38	10	12
32	40	38	10	12

Subject B

Baseline

The graphs in Figures 4.2a and 4.2b present the number of correct responses of Subject B for multiplication and division facts made during the fifteen day baseline phase. The initial level of correct responding in multiplication began at 80%, gradually decreased, and then stabilized. The mean percent in multiplication and division was 55.3% (range 20%-80%) and 36% (range 0%-50%).

The raw baseline data for Subject B is presented in Table 4.6. From that table it can be seen that the correct responses of Subject B in multiplication problems were as follows: 2 out of 10 problems on Day 16, 4 out of 10 problems on Day 19, 5 out of 10 problems on Days 5, 8, 14 and 15, 6 out of 10 problems on Days 2, 6, 7, 9, 13, 20 and 21, 7 out of 10 problems on Day 12 and 8 out of 10 problems on Day 1.

In division problems he scored none correctly out of 10 problems on Day 1, but scored 2 out of 10 problems correctly on Days 6, 7, 12, and 13. His correct responses for the other remaining Days were as follows: 4 out of 10 problems on Days 2 and 3, 5 out of 10 problems on Days 8, 14, 15, 19, and 21, and 6 out of 10 problems on Day 16.

Subject B

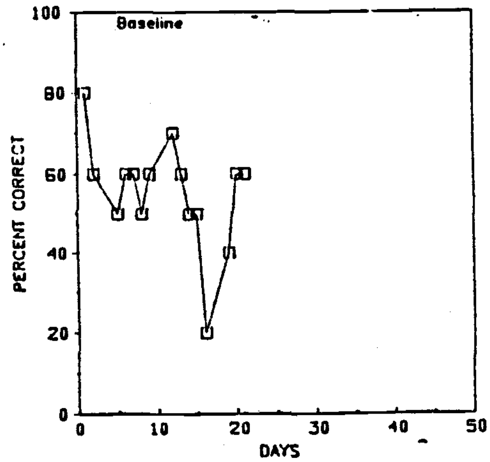

Figure 4.2a The percentage of correct responses Subject B made in multiplication facts during baseline phase.

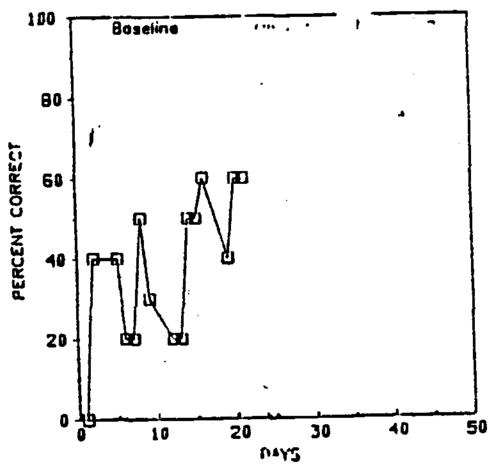

Figure 4.2b The percentage of correct responses Subject B made in division facts during baseline phase.

Table 4.6

Baseline Data for Subject B*

Day	#correct responses Mult.	Divn.	# incorrect responses Mult.	Divn.
1	8	0	2	10
2	6	4	4	6
5	5	4	5	6
6	6	2	4	8
7	6	2	4	8
8	5	5	5	5
9	6	3	4	7
12	7	2	3	8
13	6	2	4	8
14	5	5	5	5
15	5	5	5	5
16	2	6	8	4
19	4	5	6	5
20	6	5	4	5
21	6	5	4	5

* 10 problems each in multiplication and division facts

Training

Subject B was excited, enthusiastic, and required only five-minute-long sessions, one each day for five days. Training was stopped when the subject was able to play the games by himself without the investigator's help.

Intervention

Graphs in Figures 4.2c and 4.2d present the number of correct responses in multiplication and division facts that Subject B made during intervention phase. In multiplication facts, Subject B showed variability in correct responses, ranging between 72% and 84% at the beginning of the intervention. However, correct responses stabilized at 84% on multiplication facts. On division facts, the variability was low. There was 7.69% overlap in the number of correct responses in multiplication and division facts between baseline and intervention phases with levels stabilizing at 84% on Day 45 for multiplication and on Day 42 for division facts. Mean percent of correct responses in multiplication and division facts was 82.76% (range 72%-84%) and 75.52% (range 30%-80%).

Intervention

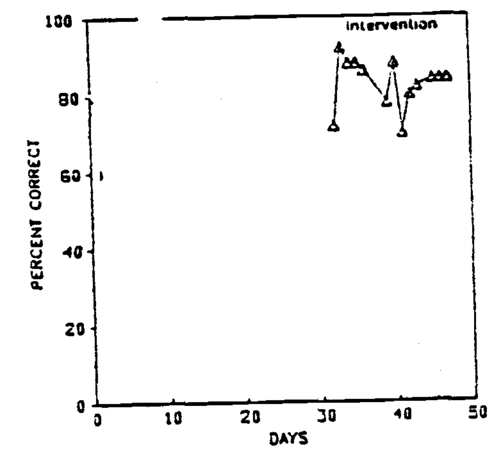

Figure 4.2c The percentage of correct responses Subject B made in multiplication facts during intervention phase.

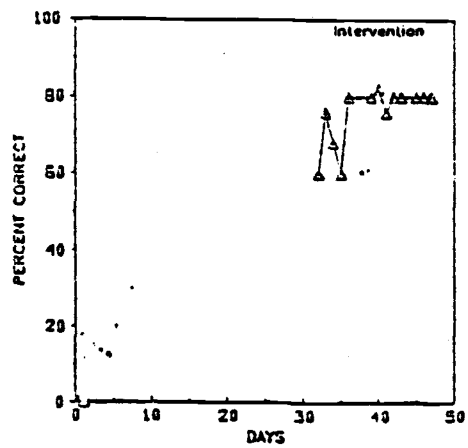

Figure 4.2d The percentage of correct responses Subject B made in division facts during intervention phase.

The intervention data for Subject B is presented in Table 4.7. From that table it can be seen that the correct responses of Subject B in multiplication problems were as follows: 35 out of 50 problems on Day 41, 36 out of 50 problems on Day 32, 39 out of 50 problems on Day 39, 40 out of 50 problems on Day 42, 41 out of 50 problems on Day 43, 42 out of 50 problems on Day 45, 46 and 47 and 43 out of 50 problems on Day 36.

In division his correct responses were: 30 out of 50 problems on Days 32 and 35, 34 out of 50 problems correctly on Day 34, 38 out of 50 problems correctly on Days 33 and 41, 40 out of 50 problems correctly on Days 36, 39, 42, 43, 45, 46 and 47, and 47 out of 50 problems correctly on Day 40.

Maintenance

Follow up assessment for Subject B was conducted exactly thirty days after the intervention. The percentage of scores in multiplication and division facts were 82% and 60%, respectively. Raw data for maintenance is presented in Table 4.3. The scores were well above the pretest but little above the post-tests scores.

Table 4.7

Intervention Data for Subject B*

DAY	# correct responses Mult.	Divn.	#incorrect responses Mult.	Divn.
32	36	30	14	20
33	46	38	4	12
34	44	34	6	16
35	44	30	6	20
36	43	40	7	10
39	39	40	11	10
40	44	41	6	9
41	35	38	15	12
42	40	40	10	10
43	41	40	9	10
45	42	40	8	10
46	42	40	8	10
47	42	40	8	10

* 50 problems each in multiplication and division facts.

Subject C

Baseline

Graphs in Figures 4.3a and 4.3b present the number of correct responses in multiplication and division facts made by Subject C during the twenty days of baseline phase. There were slight upward drifts in baseline data at the end of the phase in both the facts. Mean percent of correct responses in multiplication and division facts was 50.5% (range 40%-70%) and 14.5% (range 10%-70%).

The raw baseline data for Subject C is presented in Table 4.8. From that table it can be seen that the correct responses of Subject C in multiplication problems were as follows: 4 out of 10 problems on Days 6, 8, 12, 14, 16, 19, 21 and 32, 5 out of 10 problems on Days 9, 13, 15, 20 and 36, 6 out of 10 problems on Days 5, 7, 33, 39 and 41, and 7 out of 10 problems on Days 2 and 34.

Her correct responses in division problems were as follows: 1 out of 10 problems on Day 12, 2 out of 10 problems on Days 2, 7, 13, 14 and 16, 3 out of 10 problems on Days 8, 9 and 15, 4 out of 10 problems on Days 6, 19, 20, 21, 32 and 33, 5 out of 10 problems on Days 5 and 34, 6 out of 10 problems on Days 36 and 41, and 7 out of 10 problems on Day 39.

Subject C

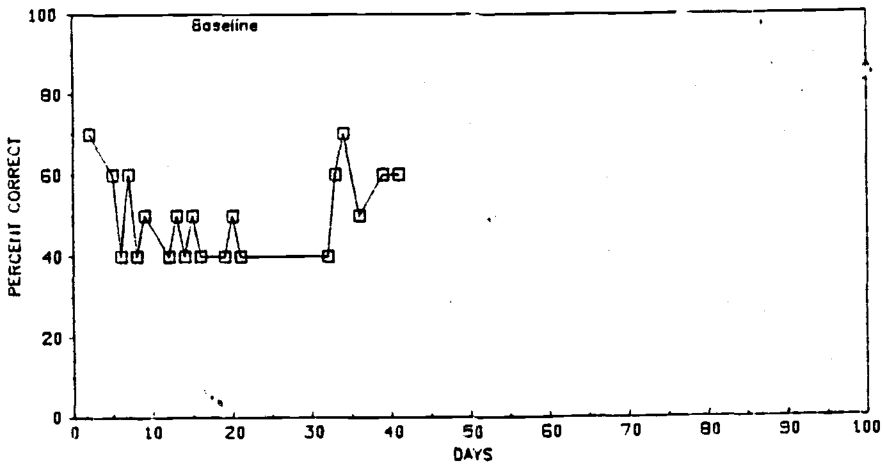

Figure 4.3a The percentage of correct responses Subject C made in multiplication facts during baseline phase.

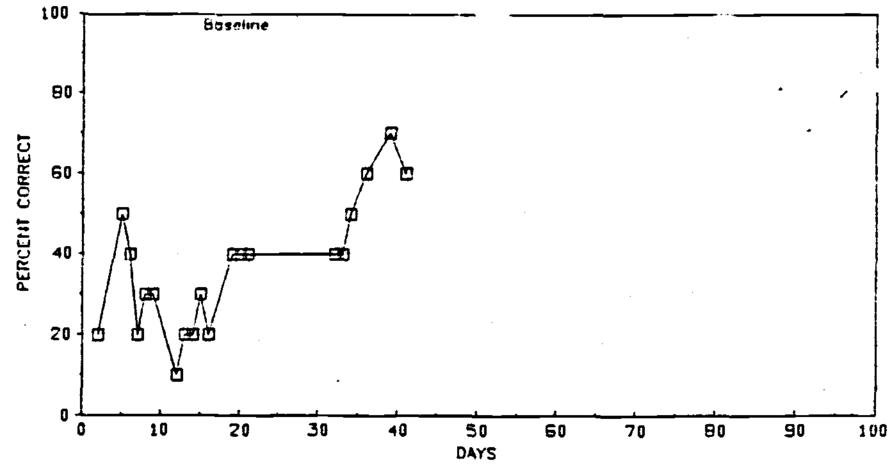

Figure 4.3b The percentage of correct responses Subject C made in division facts during baseline phase.

Table 4.8

Baseline Data for Subject C*

Day	# correct responses Mult.	Divn.	#incorrect responses Mult.	Divn.
2	7	2	3	8
5	6	5	4	5
6	4	4	6	6
7	6	2	4	8
8	4	3	6	7
9	5	3	5	7
12	4	1	6	9
13	5	2	5	8
14	4	2	6	8
15	5	3	5	7
16	4	2	6	8
19	4	4	6	6
20	5	4	5	6
21	4	4	6	6
32	4	4	6	6
33	6	4	4	6
34	7	5	3	5
36	5	6	5	4
39	6	7	4	3
41	6	6	4	4

* 10 problems each in multiplication and division

Training

Irregular attendance due to illness caused Subject C's training to be delayed until Day 60 of the intervention. She required only six training sessions, one each day. Each training session lasted five to six minutes. Training was stopped when the subject was able to play the games without the investigator's help.

Intervention

Graphs in Figure 4.3c and 4.3d present the number of correct responses in multiplication and division facts made during the intervention phase. The data depict a low variability at the beginning of the phase and increased gradually to the 80% level. There was no overlap (Overlap means the number of data points in intervention phase which fall within the range of values of baseline phase.) in the number of correct responses between baseline and intervention phases and the level stabilized at 84% on Day 98 for both multiplication and division. Mean percent of correct responses in multiplication and division was 80.10% (range 72%-86%) and 78% (range 72%-84%).

Intervention

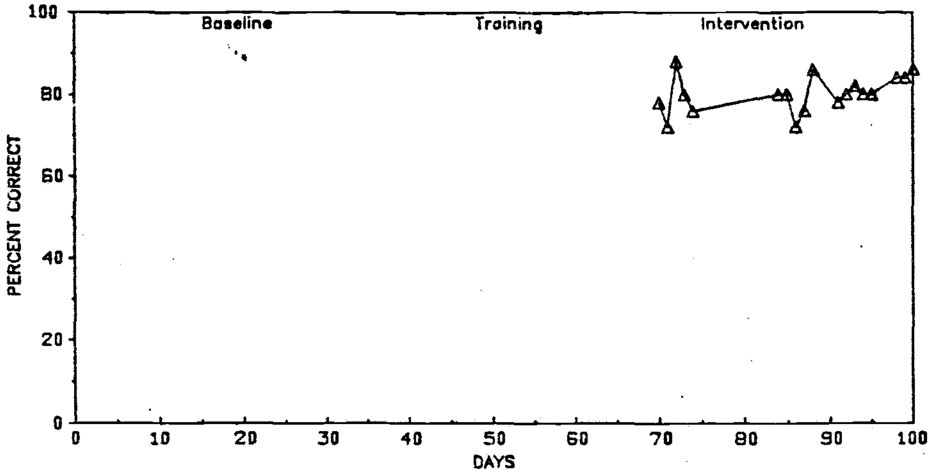

Figure 4.3c. The percentage of correct responses Subject C made in multiplication facts during intervention phase.

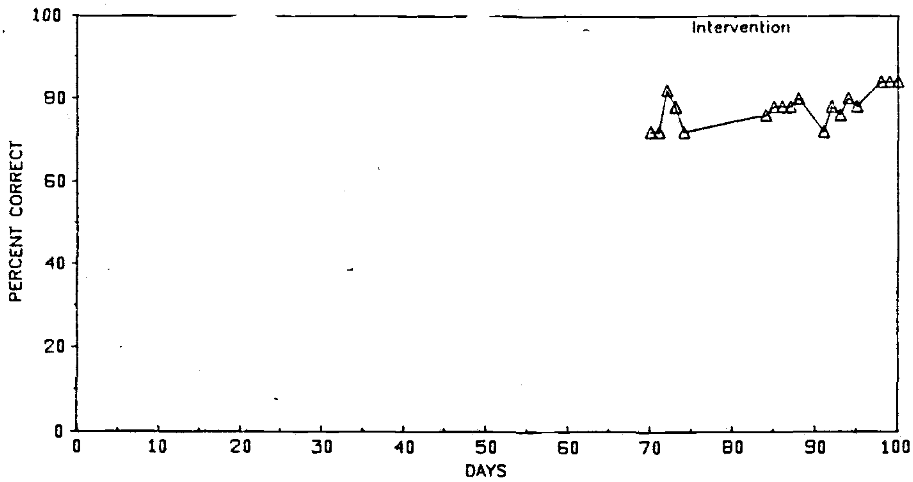

Figure 4.3d. The percentage of correct responses Subject C made in division facts during intervention phase.

The raw intervention data for Subject C are presented in Table 4.9. From that table it can be seen that the correct responses of Subject C in multiplication problems were as follows: 36 out of 50 problems on Days 71 and 86, 38 out of 50 problems on Days 74 and 87, 39 out of 50 problems on Days 70 and 91, 40 out of 50 problems on Days 73, 84, 85, 92, 94, and 95, 41 out of 50 problems on Day 93, 42 out of 50 problems on Days 98, 99 and 100, 43 out of 50 problems on Day 88, and 44 out of 50 problems on Day 72.

Her correct responses in division were as follows: 36 out of 50 problems on Days 70 and 71m 38 out of 50 problems on Days 84 and 93, 39 out of 50 problems on Days 73, 85, 86, 87, 92 and 95, 40 out of 50 problems on Days 88 and 94, 41 out of 50 problems on Day 72, and 42 out of 50 problems on Days 98, 99 and 100.

Maintenance

Follow up assessment for Subject C was conducted exactly thirty days after the termination of intervention. The percentage of scores in multiplication and division were 78% and 72%, respectively. The raw data is presented in Table 4.3. The scores in multiplication and division were well above the pre-test scores but a little below the post-test scores.

Table 4.9

Intervention Data for Subject C*

Day	# correct responses Mult.	Divn.	# incorrect responses Mult.	Divn.
70	39	36	11	14
71	36	36	14	14
72	44	41	6	9
73	40	39	10	11
74	38	36	12	14
84	40	38	10	12
85	40	39	10	11
86	36	39	14	11
87	38	39	12	11
88	43	40	17	10
91	39	36	11	14
92	40	39	10	11
93	41	38	9	12
94	40	40	10	10
95	40	39	10	11
98	42	42	8	8
99	42	42	8	8
100	42	42	8	8

* 50 problems each in multiplication and division

Subject D

Baseline

Graphs in Figures 4.4a and 4.4b present the number of correct responses made by Subject D in multiplication and division facts during the thirty-seven day baseline phase. There were no upward trends in multiplication facts except that increases were seen on Days 35, 53, and 54. The correct responses remained under 50% in spite of the extended baseline. Correct responses to the division facts reached its highest (40%) on Days 60 and 86; this percentage was not exceeded on any other days. Mean percent of correct responses in multiplication and division was 30.8% (range 10%-50%) and division was 15.1% (range 0%-40%). The raw baseline data for Subject D is presented in Table 4.10. From that table it can be seen that the correct responses of Subject D in multiplication problems were as follows: 1 out of 10 problems on Days 14, 21 and 88, 2 out of 10 problems on Days 9, 20 23, 33, 39, 60, 61, 73, 78 and 93, 3 out of 10 problems on Days 2, 13, 28, 29, 70, 84, 91 and 94, 4 out of 10 problems on Days 7, 8, 34, 41, 43, 52, 74, 86 and 94, 5 out of 10 problems on Days 1, 6, 27, 53 and 54, 6 out of 10 problems on Day 35.

His correct responses in division were as follows: 0 out of 10 problems on Days 2, 20, 21, 28, 29, 41, 43, 52, Subject D

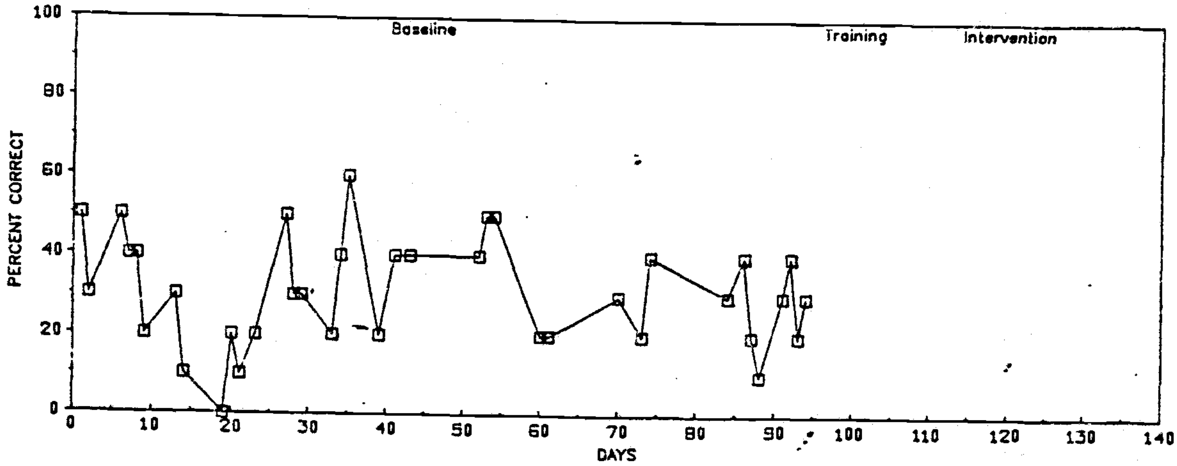

Figure 4.4a The percentage of correct responses Subject D made in multiplication facts during baseline phase.

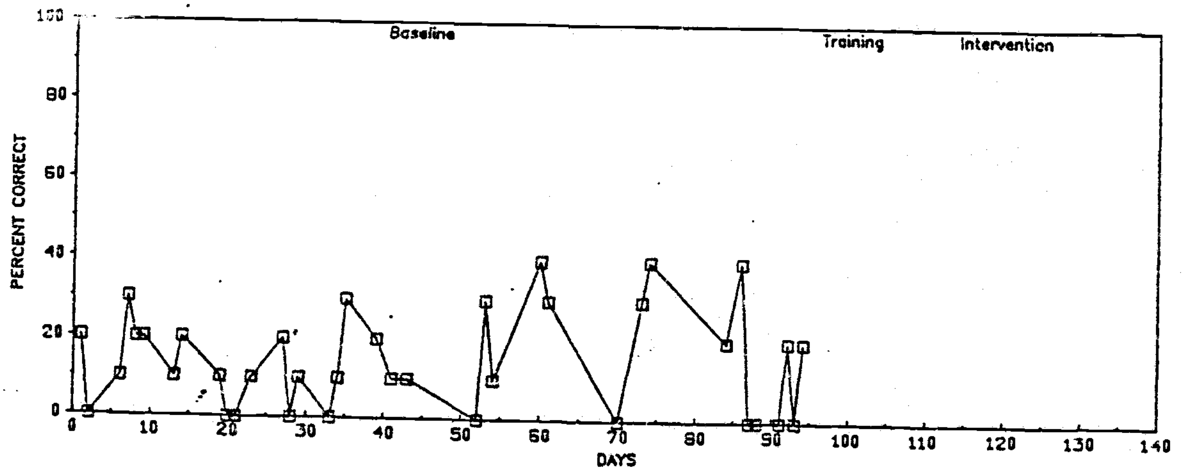

Figure 4.4b. The percentage of correct responses Subject D made in division facts during baseline phase.

Table 4.10

Baseline Data for Subject D*

Day	# correct responses Multi.	Divn.	# incorrect responses Multi.	Divn.
1	5	2	5	8
2	3	0	7	10
6	5	1	5	9
7	4	3	6	7
8	4	2	6	8
9	2	2	8	8
13	3	1	7	9
14	1	2	9	8
19	0	1	10	9
20	2	0	8	10
21	1	0	9	10
23	2	1	8	9
27	5	2	5	8
28	3	0	7	10
29	3	1	7	9
33	2	0	8	10
34	4	1	6	9
35	6	3	4	7
39	2	2	8	8
41	4	1	6	9
43	4	1	6	9

52	4	0	6	10
53	5	3	5	8
54	5	1	5	9
60	2	4	8	6
61	2	3	8	7
70	3	0	7	10
73	2	3	8	7
74	4	4	6	6
84	3	2	7	8
86	4	4	6	6
87	2	0	8	10
88	1	0	9	10
91	3	0	7	10
92	4	2	6	8
93	2	2	8	8
94	3	2	7	8

* 10 problems each in multiplication and division

70, 87, 88 and 91, 1 out of 10 problems on Days 6, 13, 19, 23, 29, 41, 43 and 54, 2 out of 10 problems on Days 1, 8, 9, 14, 27, 39, 84, 92, 93 and 94, 3 out of 10 problems on Days 7, 35, 53, 61 and 73.

Training

Subject D required only six days to train. Each training session lasted five to six minutes. Training was stopped when the subject was able to play both games by himself without the investigator´s help.

Intervention

Graphs in Figures 4.4c and 4.4d present the number of correct responses Subject D made in multiplication and division facts during the intervention phase. The data show a gradual increase of correct responses in both multiplication and division facts. Responses stabilized at around 80% for multiplication and at around 70%-76% in division. There was a 5.88% overlap in the number of correct responses in multiplication between baseline and intervention phases, with the level stabilizing on Day 127 of the investigation at 80%. The overlap in division facts was 11.76%. Mean percent of correct responses in multiplication

Intervention

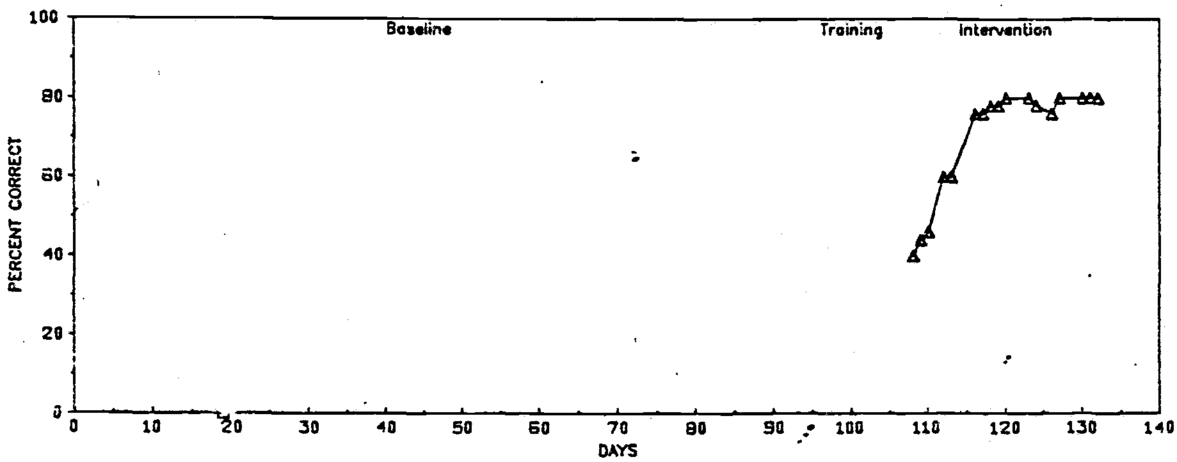

Figure 4.4c The percentage of correct responses Subject D made in multiplication facts during intervention phase.

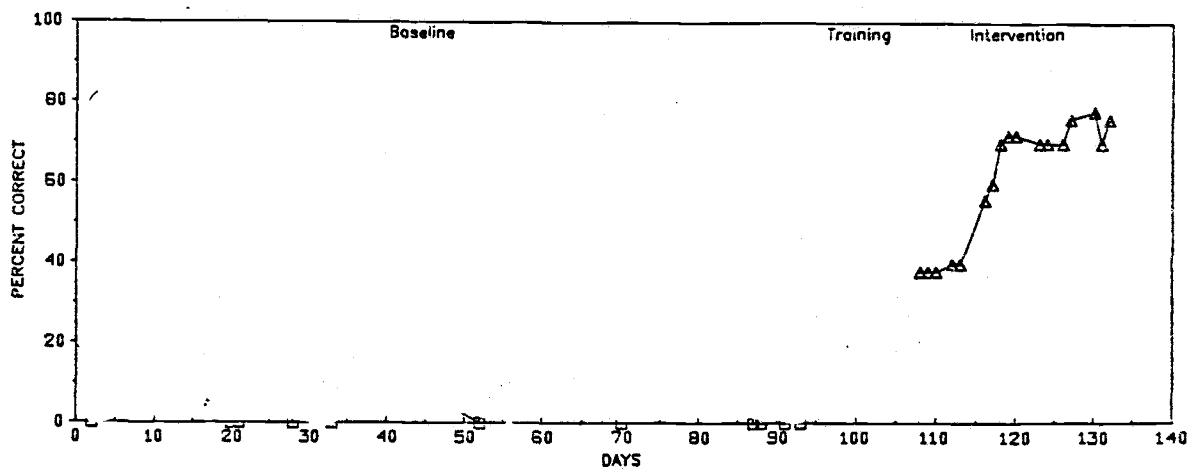

Figure 4.4d The percentage of correct responses Subject D made in division facts during intervention phase.

and division facts was 76.7% (range 40%-80%) and 56.7% (range 38%-76%).

The raw intervention data for Subject C are presented in Table 4.9. From that table it can be seen that the correct responses of Subject C in multiplication problems were as follows: 36 out of 50 problems on Days 71 and 86, 38 out of 50 problems on Days 74 and 87, 39 out of 50 problems on Days 70 and 91, 40 out of 50 problems on Days 73, 84, 85, 92, 94 and 95, 41 out of 50 problems on Days 93, 42 out of 50 problems on Days 98, 99 and 100, 43 out of 50 problems on Days 88, and 44 out of 50 problems on Day 72.

Her correct responses in division were as follows: 36 out of 50 problems on Days 70 and 71, 38 out of 50 problems on Days 84 and 93, 39 out of 50 problems on Days 73, 85, 86, 87, 92 and 95, 40 out of 50 problems on Days 98, 99 and 100.

Maintenance

Follow up assessment for Subject D was conducted exactly thirty days after the termination of intervention. The percentage of scores in multiplication and division were 54% and 40%, respectively. The raw data for maintenance is presented in Table 4.3. The scores in multiplication and division were very much above the pre-test scores.

Table 4.11

Intervention for Subject D*

Day	# correct responses Multi.	Divn.	# incorrect responses Multi.	Divn.
108	20	19	30	31
109	22	19	28	31
110	23	19	27	31
112	30	20	20	30
113	30	20	20	30
116	38	28	12	22
117	38	30	12	20
118	39	35	11	15
119	39	36	11	14
120	40	36	10	14
123	40	35	10	15
124	39	35	11	15
126	38	35	12	15
127	40	38	10	12
130	40	39	10	11
131	40	35	10	15
132	40	38	10	15

* 50 problems each in multiplication and division

Responses made by each subject in multiplication facts

Figure 4.5 shows the number of correct responses made by Subjects A, B, C, and D in multiplication facts. The data show that the number of correct responses increased during the intervention phase. With each subject, the data in the intervention phase exceeded the baseline measurements and remained stable at the end of the intervention phase--and also remained stable in maintenance. Subject A made an average of 60% during the baseline phase. This improved to an average score of 76.25% during the intervention and maintained at 80% exactly after thirty days. Subject B's average baseline score was 55.3%. This score increased to 82.76% when intervention was implemented. The maintenance score was 82%. The average baseline score for Subject C was 50.5%. This score increased to 80.10% and was maintained at 78%. Subject D had thirty-six sessions of baseline phase and the average was 30.8%. The average rose to 76.7% during intervention and was maintained at 54% after thirty days. Overall, Figure 4.5 indicates that all subjects demonstrated increased trends during intervention.

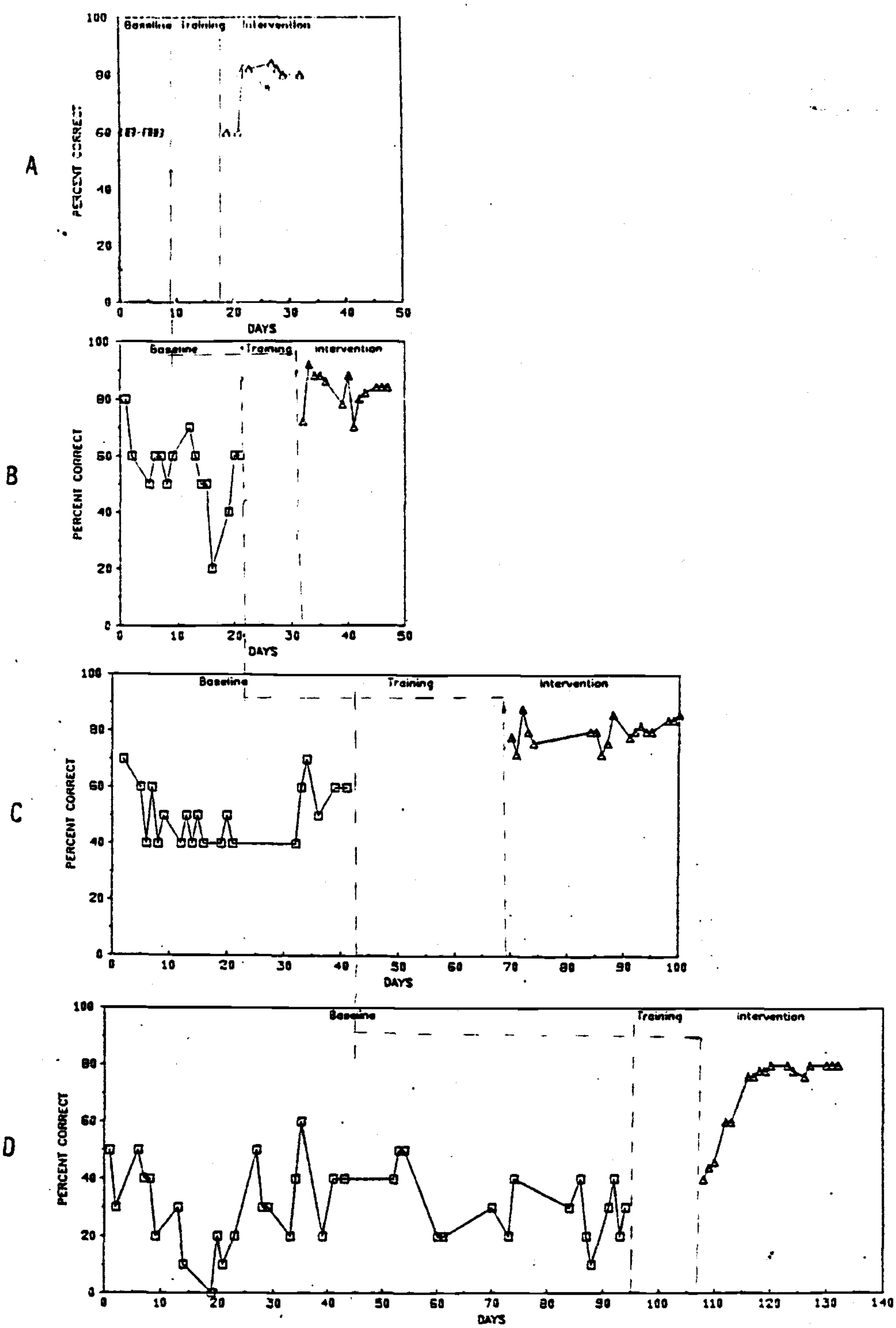

Figure 4.5 The percentage of correct responses made by Subjects A, B, C and D in multiplication facts during baseline and intervention phases.

Responses made by each subject in division facts

Figure 4.6 shows the number of correct responses made by Subjects A, B, C, and D during the intervention phase in division facts. The data show that the number of correct responses increased during intervention phase. With each subject, the data exceeded the baseline measurements. Subject A made a average score of 20% during the baseline phase. This score improved to 66.75% during intervention and was maintained at 60% exactly thirty days after intervention. Subject B's average baseline score was 36%. This increased to 75.52% when intervention was implemented. The maintenance score was 60%. The average baseline score for Subject C was 50.5%. This increased to 78% during intervention phase and was maintained at 72%. Subject D had extended baseline but the average baseline score was 15.1% This average rose to 56.7% during intervention phase and was maintained at 40%. Figure 4.6 indicates that all subjects demonstrated increased trends during intervention.

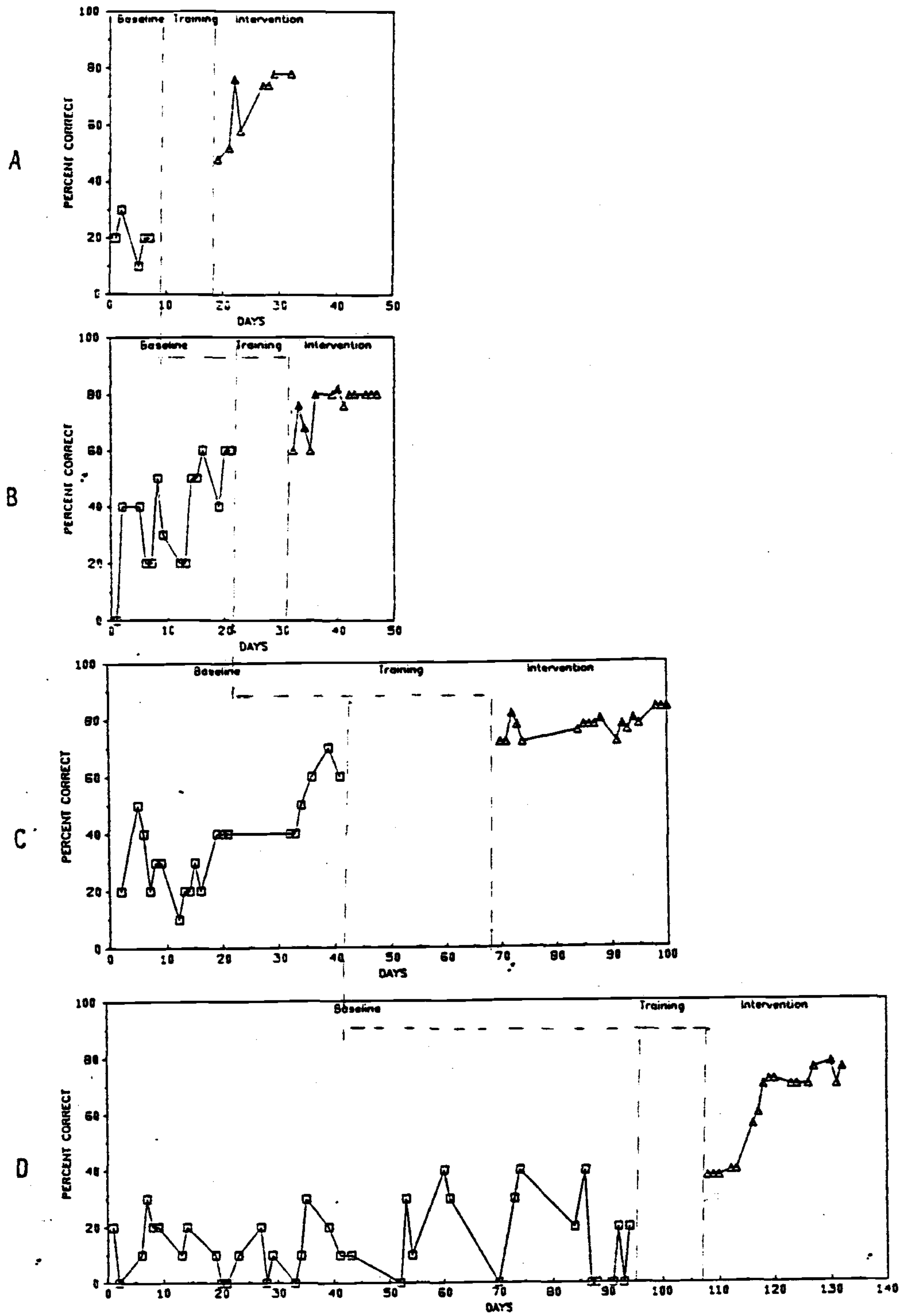

Figure 4.6 The percentage of correct responses made by Subjects A, B, C and D in division facts during baseline and intervention phases.

Summary of Results

The primary question addressed by this research was whether the use of computer games as an instructional strategy would increase achievement in basic multiplication and division facts. Relevant to this question:

1. The data for all subjects showed that the use of computer games as an instructional strategy increased achievement in basic multiplication and division facts.
2. Subjects B and D required fewer training sessions than Subjects A and C.
3. Subjects A and C took more time to train (more than ten minutes) and required more explanations, instructions, help and encouragement.
4. Each subject played all three difficulty levels of the computer games at speed 2, except for Subject B who played at speeds ranging from 2 to 4.
5. On the maintenance test, in both multiplication and division facts, each subject reached a higher number of correct responses than incorrect responses. Further, each subject's percentage of correct responses was at or above his/her pre-test correct responses.

Findings not directly related to the hypothesis.

Subjects A, C and D were tested exactly one year after the end of the intervention. The test was the same one used in pre- and post-tests. The test procedure with subjects was identical to that used in pre- and post-tests. The results were as follows: subject A scored 76% in multiplication and 60% in division facts, subject C scored 75% in multiplication and 70% in division facts and subject scored 55% in multiplication and 42% in division facts.

V. SUMMARY, CONCLUSIONS, and RECOMMENDATIONS

The study was designed to investigate the use of selected computer games as an instructional strategy with learning disabled adolescents to improve achievement in multiplication and division facts.

Summary

Four learning disabled adolescents, sixteen to eighteen years of age, enrolled in ninth grade at South Albany High School, Albany, Oregon, were selected to participate in this study. These subjects were selected on the basis of their lack of knowledge in basic multiplication and division facts. The study was conducted in the resource room of the school. The materials used in this study were the computer games software, an Apple computer, and worksheets of drill activities of multiplication and division facts. A multiple baseline design across subjects was used as the research design. A ten-minute pretest, developed by the investigator, consisting of fifty multiplication fact items and fifty division fact items randomly selected from computer games was administered to each subject. Following the pretest, the subjects were given worksheets of drill activities in multiplication and division facts. Each drill activity consisted of ten multiplication facts and ten division facts to be completed in two minutes. During this phase, baseline data was recorded for each subject. As soon as baseline data reached stability for any one of the subjects, training sessions with the computer games began for that subject. Training sessions continued until the subject was able to operate the computer and play the games himself/herself. After the training session, intervention was implemented, during which the subject played five games per skill, four or five times a week. The intervention phase had the same duration as the baseline phase (an equal number of data points existed in both phases). If no improvement was seen, or if there was a broad range of variability in the occurrence of behavior, the length of the intervention phase was extended for that subject. Meanwhile, baseline data continued to be recorded for the other three subjects.

A week later, after the first subject had completed the intervention phase, training and intervention were implemented for the next subject who displayed a stabilized baseline. Training and intervention were implemented in the same manner as for the first, while baseline data was continued to be collected for the remaining subjects. At the end of intervention, each subject was post-tested. The pre- and post-tests were identical. The data collected for each subject was graphically represented, and the means for baseline and intervention were calculated and interpreted. Reliability of the scores of pre- and post-tests and of the baseline was obtained by the investigator and by two independent raters.

Maintenance of intervention effects for each subject was tested exactly thirty days after the termination of intervention, using the same investigator-designed test that was used as the pretest.

The results indicated that this procedure for improving achievement in basic multiplication and division facts was effective. Possibly more important than the results, were the recommendations for further research efforts along this line of investigation. These findings raise challenging questions relating to the use of computer games as an instructional strategy with learning disabled adolescents.

Conclusion

The use of computer games, Meteor Multiplication and Demolition Division, was an effective strategy for increasing selected learning disabled adolescents' knowledge of multiplication and division facts. This conclusion is supported by the results presented in Chapter Four. The results suggest that the use of computer games with selected learning disabled adolescents, increased their achievement level in basic multiplication and division facts. There were greater gains (increases) in division facts than in multiplication facts. Also, one-month follow-up data revealed that all the treated adolescents maintained their gains in both the facts. Furthermore, the intervention (use of computer games) as an instructional strategy was effective with Subject D, who was physically handicapped. The results also revealed that the speed of the game was dependent on individual differences of the subjects.

Relation of this Study to Applied Behavior Analysis

The study was conducted within the conceptual framework of applied behavior analysis. Applied behavior analysis refers to the use of an intervention technique that is designed to change behavior in a precisely measurable and accountable manner. It is restricted to those interventions that include a design to assess treatment effects. The behavioral applications are analytical. Analytical behavioral application is the process of applying sometimes tentative principles of behavior to the improvement of specific behaviors, and simultaneously evaluating whether or not any changes are indeed attributable to the process of application---and if so---to what parts of that process (Baer, Wolf & Risley, 1968). It is self-examining, self-evaluative, discovery oriented research procedure for changing behavior (Baer, Wolf & Risley, 1968; Sulzar-Azaroff & Mayer, 1977).

Applied behavior analysis is purely applied research. Applied research (Sulzar-Azaroff & Mayer, 1977) is directed towards an analysis of the variables that can be effective in improving the behavior under study. It is confined to the examination of behaviors that are socially important. Applied research is usually conducted in a natural setting rather than in a laboratory. Unlike applied research, basic research (Sulzar-Azaroff & Mayer, 1977) is not directed towards the solution of practical problems. The purpose is to discover the relation between any variables, usually by conducting experiments in a laboratory setting rather than in a natural setting (Sulzar-Azaroff & Mayer, 1977).

This study meets the several criteria for applied research as stated by Baer et al. (1968a) because it was applied, behavioral, analytical, conceptual, technological, effective, and it displayed generality.

Knowledge of basic arithmetic facts is essential in order for an individual to function adequately in society. It is also important to the society itself that its members know basic arithmetic facts. Baer et al (1968) state that if behaviors are selected for study because of their importance to the individual and to society rather than for their importance to theory, they are classified as applied. In addition, the selected behaviors must be observable and measurable. Since low achievement of learning disabled adolescents in multiplication and division facts has been a long-standing problem, the selection of this behavior for study meets the criteria of being applied.

In this study, each subject demonstrated a greater number of correct responses in multiplication and division facts in post-test and maintenance phases than in the pretest phase. These results indicate that the study was behavioral since behavior was significantly altered.

This experiment meets the criteria of being analytic. Analytic refers to the believability of the research, i.e. whether or not the intervention was responsible for the occurrence or non-occurrence of the target behavior. The variables (factors) that influence believability are: reliability of the experiment, internal validity, continuous data collection and simplification and separation of components.

The reliability of the experiment variable (independent variable) was established when the behavior of each learning disabled adolescent changed maximally only upon application of the experiment variable. (Mean percent of correct responses from baseline to intervention almost doubled.)

Internal validity is the concept that the change in the dependent variable bears a direct functional relationship to the occurrence of the independent variable to the degree that, if repeated, the study would yield similar results. Campbell & Stanley (1963) note that internal validity is required in order to interpret results.

Internal validity (Baer, Wolf & Risley, 1968; Cristler, Cranston & Tucker, 1970; Haring & Phillips, 1962; Sidman, 1960) was achieved in this design by:

1) Selection of four subjects, who were functionally independent of each other, but had similar target behaviors.

2) Baseline measurement of each subject until a stable baseline was established.

3) Training each subject with computer games.

4) Application of intervention to one subject while monitoring the baseline measurements of others until an expected level was reached.

5) Application of intervention to the next subject while monitoring others.

These steps were applied to each of the subjects concurrently and sequentially and the data showed that the target behaviors of each subject were reliably changed by the intervention.

The question of whether the experiment, if repeated, would yield similar results was answered by the process of replication, which consisted of applying the same procedures across the same subjects by the same investigator. The results (the increase in the number of correct responses) were consistent across the four subjects.

Continuous data collection during baseline and intervention phases demonstrated a relationship between he dependent and independent variables over time; also change in the dependent variable was demonstrated across time. Also, continuous collection of the data provided many datum points which eliminated the drastic effects of one or two high datum points (80% of Subject B's responses in multiplication during baseline and 70% of Subject C's responses in multiplication during baseline).

The simplification and separation of components add to the analytic criteria. Intervention in this study was not made up of a single component. Instead, it consisted of computer games, feedback, motivation, self-direction, and active-participation. Thus, in this study, since the games were made up of many components, this criteria was not met.

In behavior analysis, principles of behavior are incorporated into behavior procedures to modify, increase, decrease, or maintain behavior. In this study, the study procedure followed a stimulus-student response-feedback model, and included general principles of learning. For example, the procedure included principles of active participation, immediate feedback, intrinsic motivation, immediate reinforcement, and repetitive practice. Thus, the study met the conceptual systems criterion.

Use of computer games improved achievement of the subjects in multiplication and division facts. This improvement or change in behavior did not interfere with other goals of the subjects of or the classroom. Thus, criteria of effectiveness was met by this study.

The criteria of generality was met in this investigation because the same procedures were applied across the four subjects under the same conditions at different times. The data obtained showed that what was learned in the computer games was transferred in post-test and that the change in each subject endured over time, thus, increasing confidence in the intervention technique.

Achievement of the learning disabled adolescents in arithmetic facts

Analysis of the data indicate that the introduction or use of selected computer games as an instructional strategy leads to increases in correct responses in multiplication and division facts. The changes in achievement were gradual among the four subjects and dependent on individual differences. Subject B showed a high level of response (80 percent) on the first day of baseline phase, and a variable baseline ranging from 50-60 percent at the end of the phase. The factor that may have influenced Subject B's baseline in this manner, is that he was hyperactive. Although the extended and variable baseline of Subject C showed increase in correct responses in both multiplication and division facts during the baseline phase, Subject C's intervention phase had a high number of correct responses without any overlapping of responses between baseline and intervention phases. Subject D also had a lengthy baseline phase and an overlap of 5.88 percent, both in multiplication and division facts. In spite of this, he had higher responses in multiplication and division facts.

It is important to note that the four learning disabled adolescents entered the intervention phase with a high percentage of incorrect responses in division facts, and that they subsequently showed greater gains in mastery of division facts than in multiplication facts. This corroborates the views of the makers of the games who regard high rates of error as important to the early stages of learning in order to maximize improvement. The errors are viewed as opportunities for improvement, rather than as indicators of failure. Strategies for improvement are emphasized.

The subjects did not often complete their drill assignments, but during the intervention phase, they were actively involved in the computation of arithmetic facts and scored a higher percentage of correct responses. Speed, or frequency of performance, is an important consideration for learning and is as important as the accuracy of the performance (White & Haring, 1976; Haughton, 1972). Ignoring the speed at which a subject can execute accurate responses may result in several negative consequences.

First, students are frequently advanced prematurely on the basis of performances which were accurate but also were slow and tedious. Hence, the degree of mastery necessary to ensure that the student can perform with ease and confidence, retain his or her skill, and use it to build more complex skills, is never achieved. Secondly, a student who can respond at a higher speed has more opportunities to experience and practice a skill than one who is performing at a lower speed. Considering this, Subject B performed at a rapidity of four and scored accurately. This suggests that he was able to perform rapidly and accurately without pausing to think. The remaining subjects, though actively involved, scored accurately but did not perform well when speed was increased. Although the current study was not concerned with the speed of performance, this factor should be considered in future analyses.

Computer games as a supplement to traditional teaching.

The conclusion drawn from the study suggests that the computer games had a high motivational influence on the four learning disabled adolescents. One can criticize the popularity of computer games as a fad, like so many other curriculum innovations. However, few curriculum innovations have included such an instructional tool with such diversity of applications across the disciplines and potential for creative exploration by both the teacher and the student. It is too soon to adequately evaluate the educational value of this tool, but the popularity and positive reactions from students cannot be denied.

Games create "intrinsic motivation" (Malone, 1980), because of the presence of goals, challenge and fantasy in the games. This motivational appeal was seen during the training and intervention phases. During these phases, the subjects appeared to adapt themselves easily to the mechanics of the games. Their interest remained high throughout all the sessions. There were no withdrawals. All subjects indicated at first that they were unfamiliar with the games and Subject A exhibited nervousness at the beginning. Subjects B and D wanted to play longer. An important feature of the games is that subjects received feedback regarding performance after each game (updated scores on the screen). Another feature was that the games improved motor skills of the subjects, especially those of Subject D.

The most important feature of these games was the active involvement of the subjects and repetition in the computation of multiplication and division facts. High rates of correct responses were maintained during the game. Hall et al. (1977) found in several different studies that increasing a student's opportunity to respond often resulted in academic gains. The relevant, assigned material on the game format held their attention more than the ones on drill sheets. In a game format, the subject receives more repetition in a given task then he/she would have in a drill activity.

The attributes of computer games, i.e. high motivation, active involvement, repetitive work intrinsic motivation, feedback and improvement of motor skills, and the higher scores in post-test and maintenance prove (reveal) that games may provide a positive supplement to traditional teaching methods.

Recommendations

In the classroom

This research study shows that computer games may be considered as an effective supplemental instructional technique for increasing learning disabled student's achievement in basic multiplication and division facts in a classroom. On the basis of the data presented in this study, the researcher recommends that considerations be given to:

1. Use of computer games as an efficient instructional procedure for improving mastery of basic multiplication and division facts. The procedure is effective and easily implemented. Furthermore, the games proved enjoyable for both the subjects and the investigator. Extensions of games to other arithmetic facts or skills for learning disabled adolescents is a viable possibility (Chaffin, 1982).
2. Increasing the awareness of educators at all levels regarding computer game capabilities. It is not enough to supply games to teaching personnel and assume they will be used.
3. Procedures that will alter the attitudes of teachers. Active cooperation of teachers is vital, but

unfortunately it is not always easy to obtain. One possible obstacle to cooperation is the fact that the reward structure for teachers rarely motivates them to implement change (Oettinger, 1969). Teachers can be induced to adopt change, especially if the change increases motivation and student competence. As indicated in this study, use of computer games does produce these effects.

4. Use of computers as tools for storing information regarding achievement or progress of students.

5. Use of computers for practice or drill activities thus giving teachers more time with other students. Appropriate games can be developed for efficient and effective use by a classroom teacher. Consideration should be given to the provision of competent resource personnel to develop specific games for classroom teachers. Consideration should also be given to a schedule which includes assigning students to a daily time to interact with a computer in either a corner of the classroom or in the resource room, where independent materials or other aids are used.

For future research

Based on the results of this study, the researcher sees several possibilities for future research.

1. Use of different games. The computer games used in this study were a key factor in the success of the study's basic facts-achievement effort. While use of these games was successful, perhaps use of others could be more successful. Consideration should be given to a study of a variety of games.
2. Length of intervention phase. At the end of the intervention phase, Subjects C and D appeared tired of the games, perhaps as a result of elongated intervention. Research concerning the appropriate number of days for use of the game technique would yield additional valuable information.
3. Sex-related aspects. Observation in this study indicated that female subjects (Subjects A and C) showed reluctance to play the games. Both required more days to train. Consideration should b e given to a study of attitudes of female students toward computer games.
4. Relationship of speed to accuracy. Another area for future study concerns the relationship of speed or frequency of performance to accuracy of performance.
5. Use of computer games with students without learning disabilities. Since the use of computer games with learning disabled adolescents has been successful, consideration should be given to a study of computer

games with adolescents without learning disabilities.

6. Repetition of this study with other learning disabled students. Repetition of this study with other learning disabled students would increase the generalization of the results.

7. Replication of the study in different setting. The current was conducted in the resource room of the school. Research concerning the different settings (e.g., special education classroom and regular mathematics classrooms) for use of the game technique would yield additional valuable information.

8. Use of other regular games. While use of computer games with learning disable d adolescents was successful, use of other regular mathematical games should be considered with learning disabled adolescents.

9. Relationship of speed to achievement. Responding correctly at a higher speed leads to mastery of the subject (White & Haring, 1976; Haughton, 1972). Consideration should be given to the study of relationship between the effects of speed of the games and the achievement using the computer games.

10. Previous experience with the computer games. The current study was not concerned with the adolescent's previous experience with computer games.

However, the previous experience would be indicative of increased achievement.

11. Relationship between the characteristics of learning disabled adolescents and how they play computer games. In this study, the way each subject played the game depended on his/her individual characteristics. Consideration should be given to this relationship.

12. Relationship between characteristics of learning disabled adolescents and the achievement using computer games. Since the achievement of each learning disabled adolescent in multiplication and division facts depended on his/her individual characteristics, the relationship between characteristics of learning disabled adolescents and the achievement using computer games should be studied in the future.

BIBLIOGRAPHY

Alley, G., & Deshler, D.D. Teaching the learning disabled adolescent: Strategies and methods. Denver: Love, 1979.

Ashlock, Robert B., Error Patterns in Computation. (Columbus, OH: Merrill, 1972).

Baer, D. M. Reviewer's Comment: Just because it's reliable doesn't mean that you can see it. Journal of Applied Behavior Analysis, 1977, 10 (1) 117-119.

Baer, D, M., Wolf M. M., & Risley, T. R. Some current dimensions of applied behavior analysis. Journal of Applied Behavior Analysis. 1968, 1, 91-97.

Bar-Adon, A. Child bilingualism in an immigrant society: Implications of borrowing in the Hebrew language of games. Quebec: Label University International Center on Bilingualism, 1971. (ERIC Document Reproduction Service No. ED 061809).

Biggs, Edith E. and MacLean, James R. Freedom to Learn: An Active Learning Approach to Mathematics. (Don Mills, Ontario, Canada, Addison-Wesley Ltd., 1969).

Biggs, John: The psychopathology of arithmetic, In F. W. Land., (Ed.) New Approaches to Mathematics Teaching, (London, Macmillan and Co., Ltd., 1963).

Billings, K. "Microcomputers in Education: Now and in the Future." Microcomputing (June 1980): 100-102.

Bornstein, P. H., & Quevillon, R. P. The effects of a self-instructional package on overactive preschool boys. Journal of Applied Behavior Analysis, 1976, 92,179-188.

Bowman, R. A. "Pac-Man Theory of Motivation: Tactical implications for classroom Instruction: Educational Technology. Sept. 1982. VXXII No. 9.

Brooks, D. "Video games and Human Development" Oral presentation at Harvard Conference, May 1983.

Brown, V. Learning about mathematics instruction. Journal of Learning Disabilities. 1975, 8, 476-485.

Cawley,J. F. An instructional design in mathematics. In L. Mann, L. Goodman, & J. L. Wiederholt (Eds.), Teaching the learning disabled adolescent. Boston: Houghton-Mifflin, 1978.

Cawley, J. F., Fitmaurice, A. M., Shaw, R. A., Kahn, H., & Bates, H. LD youth and mathematics: A review of characteristics. Learning Disability Quarterly. 1979.2, 29-44.

Chaffin, J. D., & Ruggles, M. E. Field test results of microcomputers. Software based on video game formats. National Educational Computing conference, Kansas City, Mo, June 29, 1982.

Chalfant, J. C., and Scheffelin, M. A. Central processing dysfunctions in children: A review of research (NINDA Monograph No. 9, U. S. Department of Health, Education and Welfare). Washington, D. C. U. S. Government Printing Office, 1969.

Clark, L. N. Playing around: Benefils; assessments and guidelines for adolescents' educational games. The Clearing House. 1978, 52, 107-110.

Combs, A. Fostering Maximum Development of the Individual. In W. Van Til (Ed.), Issues in Secondary Education. Chicago: The University of Chicago Press, 1976.

Csikzentmihalyi, M., and Larson, R. Intrinsic Rewards in School Crime. In. M. Erble (Ed.), Dealing in Discipline. Omaha: University of Mid-America, 1980.

Deshler, D. D. Learning disability in the high school student as demonstrated in monitoring of self-generated and externally generated errors. Unpublished doctoral dissertation, University of Arizona, 1974.

Deshler, D. D. Psychoeducational aspects of learning disabled adolescents. In Teaching the Learning Disabled Adolescent, edited by L. Mann, L. Goodman, and J. L. Wiederholt. Boston: Houghton-Mifflin, 1978.

Edgar, E. and Billingsley, F. Believability When N = 1. The Psychological Record, 1974, 24, 147-160.

Gagne, R. M., & Briggs, I. J. Principles of instructional design (2nd Ed.). New York: Holt and Winston, 1979.

Greenfield, P. Oral presentation at Harvard Conference, May 1983.

Gruber, B., Reeser, R., & Reid, D. H. Providing a less restrictive environment for profoundly retarded persons by teaching independent walking skills. Journal of Applied Behavior Analysis, 1979, 12(2), 285-297.

Hall, K. E., & Knight, J. Continuing education (in-service) for teachers via computer assisted instruction: Final report (Bureau of Education for the Handicapped). University Park, PA: Pennsylvania State University, Computer Assisted Instruction Lab., 1975 (ERIC Document Reproduction Service No. ED III 327.

Hall, R. V., Gristler, C., Ganstron, S. S., and Tucker, B. Teachers and parents as researchers using multiple baseline designs. Journal of Applied Behavior Analysis, 1970, 3, 247-255.

Haring, N. G., & Phillips, E. L. Educating emotionally disturbed children. New York: McGraw-Hill, 1962.

Hersen, M. and Barlow, D. H. Single case experimental designs: Strategies for studying behavior change. New York: Pergamon, 1976.

Horner, R. D., & Baer, D. M. Multiple probe technique: A variation of the multiple baseline. Journal of Applied Behavior Analysis, 1978, 11(1), 189-196,

Houghton, E. Aims-growing and sharing. I. J. B. Jordon & L. S. Robbins (Eds.), Let's try doing something else kind of thing. Arlington, VA: The Council for Exceptional Children. 1972.

Johnson, D. & Myklebust, H. Learning Disabilities: Educational principles and Practices. New York: Grune & Stratton, 1967

Johnson, S. W. Arithmetical and learning disabilities: Guidelines for identification and remediation. Boston: Allyn & Bacon, 1979.

Kazdin, A. E. Behavior modification in applied settings (2nd ed). Homewood, ILL: Dorsey, 1980.(a).

Kazdin, A. E. Single Case research design. New York: Oxford: Oxford University Press, 1982.

Kazdin, A. and Kopel, S. On resolving ambiguities in the multiple baseline design: Problems and recommendations. Behavior Therapy, 1975- 1976, 601-608.

Kennedy, L. M., & Michon, R. L. Games for individualizing mathematical learning. Columbus. OH: Charles E. Merrill, 1973.

Keogh, B. K., & Levitt, M. L. Special education in the mainstream: A confrontation of limitations. Focus on Exceptional Children, 1976,8,1-11.

Kirby, K. C. Holborn, S. W., and Bushby, H. T. Word game bingo: A behavioral treatment package for improving textual responding to sight words. Journal of Applied Behavior Analysis. 1981, 14(3), 317-326.

Kirk, S. A. Educating Exceptional Children. Boston: Houghton-Mifflin, 1962.

Kirk, S. A. "Behavioral Diagnosis and Remediation of Learning Disabilities," pp 1-7 In Conference on Exploration into the Problems of the Perceptually Handicapped Child.

Kratochwill, T. R. (Ed.). Single Subject Research: Strategies for evaluating change: New York, Academic Press. 1978.

Lerner, J. Children with Learning Disabilities (2nd ed.) New York: Houghton-Mifflin, 1976.

Lepper, M. "Microcomputers in Education: Motivational and Social Issues", Address to American Psychological Association, Washington, D. C., 1982.

Lynch, W. J. TV Games as Therapeutic Intervention, American Psychological Association, Los Angles, 1981.

Lutzker, J. R. Reducing self-injurious behavior by facial screening. American Journal of Mental Deficiency, 1978, 82, 510-513.

Malone, T. W. What makes computer games fun? Byte, Dec 1981, pp. 258-277.

Malone, T. W. What makes things fun to learn? A study of intrinsically motivating computer games. (Palo Alto, Ca: Xerox, 1980.

Marsh, G. E., Gearheart, C. K., & Gearheart, B. R. The learning disabled adolescent: Program alternatives for secondary school. St Louis: C. V. Mosby, 1978.

Mercer, C. D. Children and adolescents with learning disabilities. Columbus, OH: Charles E. Merrill, 1979.

Montague, M. The effect of cognitive strategy training on verbal math problem solving performance of learning disabled adolescents. Ph D Dissertation, University of Arizona, 1984. Dissertation Abstracts International, 1984, 45, 1096A.

Nunnally, J. Psychometric theory. New York: McGraw-Hill, 1967.

Paivio, A. Imagery and verbal processes. New York: Holt, 1971.

Parsonson, B. S., & Baer, D. M. The analysis and presentation of graphic data. In T. Kratochwill. (Ed.), Single-subject research: Strategies for evaluating change. New York: Academic Press, 1978.

Prigger, S. Computer Assisted Instruction in LD Math: Abstract. Marycrest College Department of Computer Science, Davenport, Iowa.

Schmid, R. The learning disabled adolescent. In. C. D. Mercer (Ed.) Children and adolescents with learning disabilities. Columbus, OH: Charles E. Merrill, 1979.

Sidman, M. Tactics of Scientific Research. New York: Basic Books, 1960.

Skinner, B. F. Verbal behavior. New York: Appleton-Century-Crofts, 1957.

Stone, Antonia. "Scholars on Videogames" Christian Science Monitor, 1983.

Tawney, W., & Gast, D. L. Single Subject research in special education. OH: Charles E. Merrill, 1984.

Trump, J. L. and Vars, G. How Should Learning Be Organized? In. W. Van Til (Ed.), Issues in Secondary Education. Chicago: University of Chicago Press, 1976.

Verble, M. Dealing in Discipline. Omaha: University of Mid-America. 1980.

White, O. R., & Haring, N. G. Exceptional teaching: A multimedia training package. Columbus, OH: Charles E. Merrill, 1976.

Yesseldyke, J. E., & Slvia, J. Diagnostic prescriptive teaching: Two models. Exceptional Children, 1974, 41. 181-185.

APPENDIX

APPENDIX A

Table 1

General characteristics of learning disabled adolescents

Physical	general motor awkwardness hyperactivity smaller than peers
Learning style	excessive daydreaming high distractibility perceptual confusions persistent confusion short attention span impulsive decisions and judgments inflexibility toward ideas and activities
Cognitive/ Achievement	difficulty anticipating the behavior of others difficulty modifying their behavior patterns difficulty generalizing from experience difficulty interpreting and using symbols difficulty selecting from alternatives poor development of logical reasoning and abstract thinking abilities severe underachievement
Social/ Emotional	alienation from family delinquency feelings of inadequacy few established principles or ideals frustration with self immaturity inner rage passive or active aggression quickly yields to pressure secondary emotional problems truancy

Source: Schmid, R. E., in C. Mercer (ed.), Children and Adolescents with Learning Disabilities. Columbus Ohio: Charles E. Merrill Publishing Co., 1979; and Wiederholt, J. L., A report on secondary school programs for the learning disabled. Final report (Project No. H12-7145B, Grant No. OEG-0-714425). Washington, D.C.: Bureau of Education for the Handicapped, 1975.

APPENDIX B

Description of learning disabled adolescents as defined by University of Kansas Institute for Research in Learning Disabilities

- Ability and achievement test scores or written language alone reliably differentiate LD and low-achievement (LA) students.

- LD and LA youth appear to be more likely than they are different.

- LD senior high school students were perceived by their regular classroom teachers as academically inferior to LA students. No differences were noted in social and coping skills.

- The parents of LD students appear more supportive than parents of LA students.

- The LD and LA youth are more alike than different in their performance on formal aspects of written and oral expression. Spelling was the only formal feature of written language which was significantly lower for LD youth.

- LD young adults were like their non-LD counterparts in many ways. They were, however, holding jobs with less social status, less satisfied with their jobs, less involved in recreational activities, using more prescription drugs, convicted of more crimes, and had fewer aspirations for future education and training.

- LD students can acquire learning strategies to criterion using eight systematic instructional steps. They can generalize the use of these strategies to grade level materials and tasks not previously practiced (e.g., regular classroom assignments).

- Classroom observations and the perceptions of regular classroom teachers revealed that many similarities and few differences exist between LD youth and their non-LD peers with regard to study, social, and classroom behaviors.

APPENDIX C

Eligibility Criteria

"SPECIFIC LEARNING DISABILITY"

Definition: Means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken, or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. These children are unable to profit from regular classroom methods and materials without special educational help, and are, or will become, extreme underachievers. These deficits may be exhibited in mild to severe difficulties with perception (the ability to attach meaning to sensory stimuli), conceptualization, language, memory, motor skills, or control of attention. Specific learning disability includes such conditions as perceptual handicaps, brain injury, dyslexia, minimal brain dysfunction and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage.

Criteria: (a) A multidisciplinary evaluation team may determine that a child has a specific learning disability if:

(A) The child does not achieve commensurate with his or her age and ability levels in one or more of the areas listed in (5) (a) (B) or this rule, when provided with learning experiences appropriate for the child's age and ability levels.

(B) The team finds that a child has a severe discrepancy between achievement and intellectual ability in one or more of the following areas:

(i) Oral expression;
(ii) Listening comprehension;
(iii) Written expression;
(iv) Basic reading skills;
(v) Reading comprehension;
(vi) Mathematics calculation; or
(vii) Mathematics reasoning.

(b) Or Team may also determine that a child has a specific learning disability if it obtains evidence of a deficit in perception, conceptualization, language, memory, motor skills, or control of attention such as to prevent the child from profiting adequately from regular classroom methods and materials without special education help.

(c) The medical examination generally required in determining eligibility of handicapped children for special education may be waived by the school district, but a medical examination with neurological, vision, or hearing problems, or when after a period of special education help, the child has failed to make reasonalbe progress.

(d) The team may not identify a child as having a specific learning disability if the severe discrepancy between ability and achievement is primarily the result of:

(A) A visual, hearing, or motor handicap;
(B) Mental retardation;
(C) Emotional disturbance; or
(D) Environmental, cultural, or economic disadvantage.

APPENDIX D

Description of games

METEOR MULTIPLICATION: Assists students in the multiplication of numbers 0 through 9 in a "meteor shower" format. Large meteors with problems move toward a large star position in the center of the screen. Answers to the problems are placed in the center of the station, station gun is aimed, and the gun is fired to disintegrate the meteor. If the meteor reaches the star station before being disintegrated with the correct answer, the meteor shatters it in a highly graphic and sound explosion. Answers are always placed in star station using designated keys; when paddle option is selected, answers appear and must be matched to problems. Hits and misses are recorded at the bottom of the galaxy.

DEMOLITION DIVISION: Gives students an opportunity to practice the division of problems with answers 0 through 9 in a wargame format. Tanks moving from the left side of the screen with problems fire, destroying a wall surrounding the guns on right as they move toward the guns. Answers are placed beside the gun and fired at the approaching tank. If the answer is smaller than the correct, the fire falls short of the tank; if larger, it falls beyond; if correct, it destroys the tank. If the tank reaches the gun before being destroyed by the number fired, the tank destroys the gun. Answers are placed in guns using the designated keys; when the paddle option is selected, answers appear and must be matched to problems. Hits and misses are recorded in bunkers at the bottom of the screen.

APPENDIX E

Worksheet

Multiply:

1.	7 x 6 =	5 x 3 =	6 x 1 =	2 x 8 =	3 x 7 =
2.	8 x 8 =	2 x 5 =	9 x 3 =	4 x 8 =	6 x 2 =

Divide:

1.	48 ÷ 6 =	35 ÷ 5 =	12 ÷ 4 =	45 ÷ 9 =	36 ÷ 6 =
2.	48 ÷ 8 =	81 ÷ 9 =	48 ÷ 2 =	24 ÷ 4 =	12 ÷ 2 =

APPENDIX F

Investigator-made tests

Name:____________________

MULTIPLICATION

Multiply:

1.	2 x 3 =	8 x 4 =	3 x 2 =	9 x 4 =	5 x 7 =
2.	6 x 6 =	0 x 5 =	6 x 8 =	3 x 9 =	9 x 1 =
3.	4 x 4 =	8 x 3 =	5 x 1 =	4 x 2 =	0 x 7 =
4.	7 x 3 =	1 x 3 =	4 x 7 =	3 x 8 =	6 x 7 =
5.	5 x 3 =	7 x 4 =	2 x 5 =	8 x 1 =	1 x 7 =
6.	9 x 7 =	0 x 0 =	2 x 9 =	9 x 5 =	7 x 3 =
7.	7 x 7 =	6 x 9 =	9 x 6 =	5 x 4 =	3 x 3 =
8.	5 x 5 =	8 x 1 =	3 x 5 =	8 x 6 =	7 x 3 =
9.	4 x 8 =	9 x 8 =	1 x 2 =	2 x 7 =	6 x 6 =
10.	9 x 7 =	2 x 0 =	4 x 9 =	8 x 8 =	5 x 8 =

Name:____________________

DIVISION

Divide:

1.	24 ÷ 4 =	18 ÷ 9 =	35 ÷ 7 =	10 ÷ 2 =	3 ÷ 3 =
2.	0 ÷ 5 =	20 ÷ 5 =	18 ÷ 2 =	36 ÷ 9 =	6 ÷ 2 =
3.	48 ÷ 8 =	21 ÷ 3 =	6 ÷ 6 =	72 ÷ 8 =	54 ÷ 9 =
4.	27 ÷ 9 =	49 ÷ 7 =	14 ÷ 2 =	27 ÷ 3 =	32 ÷ 8 =
5.	6 ÷ 2 =	40 ÷ 5 =	36 ÷ 6 =	64 ÷ 8 =	16 ÷ 4 =
6.	81 ÷ 9 =	56 ÷ 7 =	24 ÷ 8 =	63 ÷ 7 =	40 ÷ 5 =
7.	48 ÷ 6 =	25 ÷ 5 =	27 ÷ 9 =	4 ÷ 4 =	0 ÷ 9 =
8.	24 ÷ 6 =	45 ÷ 9 =	56 ÷ 8 =	72 ÷ 9 =	28 ÷ 4 =
9.	12 ÷ 4 =	18 ÷ 3 =	48 ÷ 8 =	15 ÷ 5 =	54 ÷ 6 =
10.	36 ÷ 4 =	42 ÷ 7 =	72 ÷ 8 =	9 ÷ 3 =	1 ÷ 1 =

APPENDIX G

Program for Randomization

```
5 DIM QUEST4(100)
10 FOR I = 1 TO 100
20 READ QUEST$ (1)
30 NEXT I
40 S = PEEK (78) + PEEK (79) + 256
50 X = RND ( - S)
55 FOR I = 1 TO 50
60 R = INT (100 * RND (1) ) + 1
70 PRINT QUEST$(R);" ";
80 NEXT I
90 DATA
180 END
```

APPENDIX H

Diskette instructions

GETTING READY

1. Read all the instructions thoroughly.
2. Equipment needed Apple computer (48K, applesoft), 1 disk drive, monitor (TV).
3. Check to be sure that system components are connected correctly and plugged into wall outlet.
4. Turn volume all the way down on monitor.
5. Place diskette in drive.
6. Turn on computer; when drive begins to "whirr" and "in use" light on drive is one, snap door on drive closed.
7. When loading, screen will display:
   - DLM logo for ARCADEMICS and name of program. Adjust color.
   - Copyright notice. Adjust picture sharpness.
   - PRESS ANY KEY TO PLAY appears.

GETTING SET

- Practice with the game yourself.

- When PRESS ANY KEY TO PLAY appears on screen, you can change game control option. Diskette is programmed:

  1. at skill level 7;
  2. for problems with numbers 0-9;
  3. to run 2 minutes per game;
  4. for keyboard use, not paddles.

- To change these game options:

  1. When PRESS ANY KEY TO PLAY appears, hold down CTRL key and press P.
  2. These game options will appear:

     1. SKILL LEVEL (1...9) Speed at which the game runs. 1 is slowest; 9 is fastest.

     2. PROBLEM RANGE 3, 6, 9. Problems with numbers 0-3 (press 3); 0-6 (press 7); 0-9(press 9).

     3. RUN TIME (min). Games can run from 1 to 5 minutes each.

     4. PADDLE CONTROL. Press Y for yes; N for no.

3. Follow these directions as they appear on the screen.

   --PRESS NUMBER OF OPTION TO CHANGE (number at the left of option).
   --Flashing cursor will appear at the programmed level (number on right).
   --Type level you want of that option.
   --Program will change and relist options.
   --Change as many options as you want.
   --When all selections are made, press 5.
   --PRESS ANY KEY TO PLAY will appear.

4. Game is ready to play.

THINGS TO REMEMBER:

1. Press CTRL P to change options.

2. Press 5 to exit options.

3. You can load several computers with the same diskette by removing the diskette from the drive after game options are selected and using it to load the next system.

4. Game control options can be selected during a game by pressing CTRL P whenever scores appear on screen and diskette is placed in drive.

PLAYING

- THE GAMES. The object of each game is to destroy the problems with the correct answer before being "destroyed" by the problem.

METEOR MULTIPLICATION - Problems move from all around the screen toward center. Answers placed in center; gun at center is moved with direction to fire.

DEMOLITION DIVISION - Problems move from left to right toward gun on left. Answers placed in gun to fire.

- Answering with Keyboard. While playing the game, the play will:

  1. Place the answer in the answer graphic.
  2. Fire the answer at the problem.
  3. Move the answer graphic to the next problem.
  4. Repeat for all problems.

- Answering with Paddles. When paddle mode is selected, the answers appear automatically in the answer graphic.
  The player must match the answer to the correct problem.

  1. Determine which paddle controls the screen.
  2. Move answer to position to match problem by moving the dial knob on the paddle.
  3. Fire the answer by pressing the button on the paddle.

NOTES ON SKILL LEVEL

1. Noise and visual explosion occurs when problem reaches answer range before fired with correct answer.

2. Three explosions in a game terminates that game and scores recorded.

KEYBOARD KEYS TO USE

- Each game has several designated sets of keys that can be used for playing the game.

THE GAME OPERATES WITH ANY COMBINATION OF THESE KEYS.

- OPTION A:
  1-0 number keys = place answer
  left arrow = moves answer left; counter-clock; down
  right arrow = moves answer right; clockwise; up
  space bar = fires

- OPTION B:
  j = moves answer left; counter-clock;down
  l = moves answer right; clockwise; up
  k = increases answer number
  m = decreases answer number
  - = fires

- OPTION C:
  a = moves answer left; counter-clock;down
  d = moves answer right; clockwise; up
  s = increases answer number
  x = decreases answer number
  w = fires

• TERMINATING GAME. A game can be stopped at any time during play by pressing t key. A game is also terminated when player fails to answer in allotted time 3 times in one game.

• SCORES. After each game, scores appear.

--Scores show hits and misses for current (last game played) and highest and lowest of all games played.
--Scores continue to be recorded until computer is shut off or RESET key pressed.
--Misses recorded only when wrong answer fired; not for failure to answer in time.

WHAT IF .....

• Program does not load when computer is turned on . . .

.......this means you do not have autostart in your Apple. Type PR#6 and press RETURN.

• Program freezes on screen . . .

......type t; scores will appear. Pressing any key will start a new game.

• RESET key is pressed . . .

.......all scores are erased; game options return to programmed ones; drive will "whirr." Hold down RESET key until drive stops. Replace diskette in drive. Type PR#6 and press RETURN. Program will reload.

• Blank screen continues when loading . . .

......check all connections, especially input to monitor.

• Computer is shut off during game . . .

......game options return to programmed ones; all scores are erased. Replace diskette in drive. Turn on computer. Program will reload.

• CTRL P is pressed without diskette in drive . . .

.....drive will make "klunking" sound. After options made, game will start immediately.

APPENDIX I

Instructions for scoring reliability

1. Score each multiplication and division fact item. by comparing them with the answer key sheet.
2. Mark each correct response as , and each incorrect response as x.
3. If the response is unintelligible, mark the response as x.
4. If the response is transcribed, mark the response as x.
5. Reliability is calculated by using this formula:

$$\frac{\text{\# of correct responses}}{\text{\# of correct responses + \# of incorrect responses}} \times 100$$