1999

Memory magic for the multiplication monsters

Rebecca Ruth Mach

MEMORY MAGIC FOR THE MULTIPLICATION MONSTERS

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education: Instructional Technology Option

---

by

Rebecca Ruth Mach

September 1999

MEMORY MAGIC FOR THE MULTIPLICATION

MONSTERS

A Project

Presented to the

Faculty of

California State University,

San Bernardino

---

by

Rebecca Ruth Mach

September 1999

Approved by:

[redacted]

James Monaghan, Ph.D. | 9/1/99 Date

[redacted]

Amy Sheng Chieh Leh, Ph.D.

ABSTRACT

The purpose of this project was to develop a computer-based software program that will motivate at-risk students (including Learning Handicapped, English Language Learners/English as a Second Language Learners) to pursue through the program the goal of mastering the more difficult products within the one hundred multiplication facts (6's, 7's, 8's and 9's). This was accomplished by developing a software program that incorporates cognitive strategies appropriate to individual learning styles and strengths. By using this software program, the intent was to provide students with opportunity to transfer the more difficult of the multiplication tables from their working (short-term) memory to their long term memory. They should, also, be capable of retrieval of these facts back to their working memories. The use of technology and this easily navigated stack will increase the students' motivation to learn these more difficult facts. The students should, also, experience the hands-on portion of technology that is encouraged by the California State mathematics framework.

This project characterizes the development of a computer-based instructional program that can be used in

conjunction with mathematics core curriculum as adopted by any given district within the state. It can be used as a remedial tool to ensure that students are empowered with the basic skills necessary to enable them to develop math skills and problem solving skills to their highest potential. Using instructional cards within the stack that can combine visual, auditory, motor and musical memory strategies, students learn and apply memorized multiplication facts. There are cards within the stack that provide guided practice. Other cards provide game-like activities for additional practice. The learned facts from these lessons and activities can later be transferred to lessons and activities provided through the California State and district approved mathematics core curriculum.

ACKNOWLEDGMENT

I would like to thank Dr. James Monaghan, Dr. Amy Sheng Chieh Leh and Dr. Sylvester Robertson for their patience and expertise in the guiding to completion of this product. Their time, effort and sincerity have been major factors in helping me to culminate my dream.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

Introduction

Highly developed and technological nations must seek ways to increase the proportion of the Nation's population to develop literacy (language arts and mathematics) to that population's highest potential. Technologically oriented nations are deeply concerned with the growing shortage of talent in our society. Developing and maintaining the population's talent in both these important areas is crucial to remaining on the cutting edge of the Information Age (Cannings & Finkel, 1993).

According to the California Mathematical Task Force Report, "mathematics standards should reflect a balance of basic skills, conceptual understanding . . ." The manipulation and memorization of the symbols involved in the mathematical process of committing the multiplication facts one to one hundred to memory falls under both "basic skills" and "conceptualization." This process of understanding and then memorizing the facts is complex. The public schools that are located in California, and elsewhere, have required this skill to the mastery level by all elementary school aged children for decades.

Statement of the Problem

Traditional materials and methods are not working in teaching at-risk students to understand the process (repeated addition) and memorize the multiplication facts to mastery. Teachers focus almost exclusively on basic skill instruction and strategies to help at-risk students overcome their difficulties (Allington, 1988). The traditional strategies most often employed by teachers in assisting their students to the mastery level of memorization of the multiplication facts, according to Gaddes (1994), are the use of flash cards (visual memory), rehearsal (visual and auditory repetition), and audio, musical tape recordings (auditory/musical memory). These strategies operating in isolation do not work with at-risk students. Even the constructivists, who utilize manipulatives and hands-on experiences in their delivery are not guaranteeing that students achieve mastery learning of the multiplication facts. From my experiences as a resource specialist teacher over the past seventeen years in the California elementary schools, I have found that many of the above mentioned strategies have not been always been one hundred per cent effective in most fifth and sixth grade classrooms. In the elementary schools in which I have been teaching over the past seventeen years, I have intermittently, informally surveyed regular fifth and sixth grade teachers. They have assessed students using a multiplication pretest of the one through ten multiplication facts. Generally, these teachers would refer to me anywhere from six to ten students from their classrooms who had not yet mastered the multiplication facts from six through nine.

As a Resource Specialist working at-risk students in grades first through high school, I have developed instructional strategies that work with these students. I have the advantage of working with these students in small groups (six to eight students). I have taught motor strategies (finger tricks) that have given students instant "built in" tools for arriving at the correct products for some of the more difficult of the multiplication facts presented in the six, seven eight and nine clusters. In addition, I have utilized enlarged flash cards that combine the two cognitive strategies of visual and auditory memory.

These flash cards present the multiplication facts in a simple cartoon format designed to enable visual memory of the targeted multiplication facts each cartoon is paired with a two to three line sentence story designed to enable auditory memory of the cartoon figures and stories presented. I chunked the cartoon visuals into silly, but meaningful groupings. The majority of the at-risk students in the groups presented with these strategies went on to pass the multiplication timed tests in their respective classrooms. The students further reported to this specialist that they continued to use many of the visual, auditory, motor and musical strategies to recall the multiplication facts while doing math problems assigned by their classroom teachers. It would appear that these strategies have been successful when presented by way of direct instruction.

It is my contention as a specialist that skill building may be done with the whole class, in small groups or individually with one-to-one teacher, aide or peer assistance. It can be done with conventional classroom tools and strategies and it can be done with computers, via technology. Computers can assist in the complex task of linking the above mentioned materials and strategies. Thus, technology can make the complex task of learning the multiplication facts to the mastery level a reality for the vast majority of the at-risk students (Scott, Kahlich & Barker, 1994). In fact, one of the earliest applications of computers in the area of math instruction was in the area of drill and practice.

Need for the Project

Using instructional materials and methods that combine cognitive strategies (visual, auditory, motor) with strategies that tap into individual learning styles, multiple intelligences and learning strengths falls within the scope and capabilities of today's technology. Technology is daily becoming even more capable of engaging at-risk students and providing them with varied multi-sensory opportunities to interact with symbols of all varieties (Kozma & Cronninger, 1992). In another study, Sinatra, Beaudry, Pizzo & Geilsert (1994) found that at-risk students responded positively to the use of technology incorporated with instructional strategies and methodology.

I believe that assistance for children in the high risk of failure category may come through computer-assisted instruction (CAI), not only because software is available, but because of the computer's interactive qualities that allow students to have more control of their own learning. Computers need to be increasingly thought of as tools. Computers can sometimes provide instruction when no satisfactory alternative is available (Hornbeck, 1990). Also, according to Hornbeck, computers provide the greatest improvement for the lowest achieving students. Computer based instruction allows the student opportunities of interactivity (interactive learning). Gardner and Cochran (1993) give the definition of the term "interactivity" as "the user engaging in direct and continual two way communication with the computer, responding to questions and receiving feedback." The usefulness of the computer as an educational tool allows at-risk students to approach the learning task with a minimum of risk of failure. Also, the computer offers motivation, self- pacing and privacy (Scott, Kahlich & Barker, 1994). The computer can be non-judgmental with careful design of software. All students can be accepted where they are in their own development and guided toward the acquisition of the skills and concepts they need (Cannings & Finkel, 1993) with well-designed software applications. The computer can inform a student of success or failure without expressing by word or deed that the student is good or bad. With careful design embedded in software, the computer can individualize learning, permitting mastery at one's own pace. Again, in many instances, the student has far more autonomy than in other more traditional teacher directed settings. The computer can give prompt feedback. These qualities allow the student to feel more in charge. This is a missing quality in the lives of many students, especially of those who are at risk (Hornbeck, 1990).

Project Overview

The purpose of this project is to develop a computer-based program to motivate at-risk students to learn to the mastery stage the more difficult of the multiplication facts from the (6's, 7's, 8's and 9's). This project has been accomplished by the development of instructional material presented on a group of cards, called a stack created on HyperStudio. It integrates cognitive strategies with multiple intelligence methodologies and learning style preferences. It provides opportunities for controlled practice by presenting cards in the stack that allow the student to print worksheets, complete them and present them to the teacher. Motivation is enhanced by the presentation of game-like cards to encourage student participation and continued practice. The intent is to provide at-risk students with a visual, auditory, motor and musical presentation of stimulating activities to assist them in learning to the mastery level the most difficult of the multiplication facts in the one to one hundred range. This project involves the design and development of computer based instructional material that can be used in conjunction with the core curriculum of any mathematics classroom.

This program is different from other programs because of the uniqueness of its presentation of the facts. It utilizes visual, auditory, motor and musical memory strategy components interwoven with guided practice and game-like formats. Although motivation is a factor for all students in all subject areas, it is especially important for those who struggle and fail to learn by traditional classroom materials and methods. Because of earlier learning experiences, many of these students who have been unsuccessful, feel they cannot learn. They often lack the motivation to persist in the complex task of committing to memory the more difficult of the multiplication facts (Gentile & McMillan, 1990).

CHAPTER TWO

Review of Related Literature

This chapter reviews the following questions. Who are at-risk students? What are the characteristics of at-risk students? What are the variables involved in mastery learning? How do students learn? What is the role and impact of technology in helping at-risk students? Through a thorough investigation of the above-mentioned questions, other questions were uncovered and discussed. What is the most recent brain research telling us about effective cognitive strategies? How does the theory of multiple intelligences relate to individual differences in learners? How do theories of individual learning styles and preferences impact on educators' decisions about instructional effective strategies and materials? Ultimately, how do all of these variables interact to have an impact on the project that I have developed?

At-Risk Students

Within any set of classroom walls there will be students who struggle to master the skills and concepts presented through the curriculum. These students who are experiencing difficulties are often lumped together and given the label of "at-risk." Individual differences in learners is a given. The definitions for the term at-risk vary widely. While there are some things in common in the various definitions, the specifics depend on who supplies the definitions (Colby, 1995).

Researchers tell us that at-risk students come from every level of society (Gentile & McMillan, 1991) and that most definitions of at-risk students focus on the students' deficits (Dutweiler, 1992). The students in any given California public school would fall along a continuum ranging from "little capability" through "exceptional capability." At-risk students also could fall anywhere along the continuum depending on the factors impacting those students. Students who are labeled at-risk undoubtedly constitute a diverse group. The following discussion by Fox elaborates on this diversity.

In fact, Fox (1990) states:

> The study of children at-risk is a study of paradoxes. These children are of average intelligence . . . They and their parents have high aspirations for their success in school. Yet, these children fall behind early and fail to catch up. They participate in their own communities, but are often disengaged from the culture of the school (p.70).

These students may include young people whose cultural heritage is not consistent with the sociocultural context of the mainstream schooling (Bryson & Scardamalia,1991). Some of these students have been given additional labels such as "learning handicapped" (L.H.). Others are labeled with adherence to language acquisition criteria as "English Language Learners" (ELL).

At-risk students are sometimes products of turbulent home environments. Home environments that may include physical and/or psychological abuse by parents or other caregivers, histories of alcohol and/or drug dependence, relatives that have had traumatic or failing experiences in schools. Additionally, many at-risk students are caught in the dilemma of the economically demanding society of the twentieth century. Economic conditions often dictate the work schedules of both parents and often the older siblings as well. Many at-risk students are "latch key" children with little or no supervision and/or guidance in their lives. Sometimes two to three families share a single family dwelling for economic reasons. These conditions are often unsafe and not conducive to successful educational experiences for the children.

Researchers are not the only group concerned with at-risk students. Classroom teachers play an important role in determining that certain students are at-risk. "Teacher judgments are almost always required either to identify or confirm the designation of students as at-risk" (Payne & Payne, 1991). In fact, Assembly Bill 972 included was a bill designed to study (1986-1988) the effectiveness of a program that featured early identification of at-risk students. A legislative report examined multiple indicators, including both commercial screening tests and teacher judgments. One of the objectives of the report was to examine the effectiveness of pilot testing in correctly identifying at-risk students. This study revealed that while no single indicator was effective, teacher judgment came closest. In view of the greater effectiveness and relatively low cost of teacher judgment as an indicator of later school problems, the Department of Education recommended further developmental work to increase the effectiveness of teachers as an important means of correctly identifying at-risk students (California Department of Education Publication, 1994). Thus, we have seen the development and implementation of the Student Study Teams in our California schools over the past decade.

Parents and other caregivers as well as teachers are concerned with early identification of some of the behaviors that indicate a child is at-risk. They are concerned about the long-range consequences of such behaviors. Parents are sometimes the best resource for describing techniques and interventions that will be successful in working with the at-risk student. They often have valuable insights as they have been dealing with this child for many years (Canter, 1991). According to Berger (1981) in Parents as Partners in Education, "Parents are the one continuous force in the education of their children from birth to adulthood." It is important to nurture the school and home connection in order to assure a child's learning success and maintain school's accomplishments (Croft, 1979). Parents are becoming increasingly involved in the Student Study Team process that identifies and intervenes for the at-risk students in our California public schools.

According to a 1994 California Department of Education Publication called "I Can Learn," there are mainly two types of impressions a teacher gains from observing at-risk students who are having difficulties in class. They are having difficulties:

(1) receiving instruction (auditory processing), and

(2) expressing what he or she knows, or has learned as a result of the instruction (expressive language). Often the teachers notice that students are not retaining information once learned (memory), and not transferring the information to tasks assigned as well.

According to the previously mentioned 1994 California Department of Education publication, the characteristic behaviors that these teachers observe are:

1. The at-risk student is frustrated and/or anxious and is academically struggling. As a result, these students may be observed to act out, daydream, be unmotivated not to be trying or inattentive; these students may appear to be lazy or unhappy; they may seem to have a low self-esteem.
2. The student seems to possess adequate intelligence but continually performs below expectations.
3. The at-risk student shows a mysterious variance in performance and knowledge retention and seems to have unexplainable gaps in skills.
4. This student often finds organization and time management skills impossible.
5. The at-risk student may have difficulties with task completion both with class and homework.
6. He or she often appears to be overwhelmed with the quantity of information presented in visual, oral and/or written form.
7. The at-risk student may have difficulty engaging in tasks that require two or more simultaneous activities or multi-step processes.
8. Additionally, their response time to directives appear to be inappropriate; that is, either too rapid (impulsive) or too slow.

Dutweiler (1992) explains that most definitions of at-riskness ignore the relationship between the school and the student and changes that could be made within the educational system. Yet, with the best intentions, schools can foster conditions that guarantee a certain proportion of these students will find schooling so inhospitable they will leave. Our basic tasks as educators are to find and implement methodology and strategies that will "take individual differences into consideration, but will do so in such a way as to promote the fullest development of the individual" (Bloom, 1968). This involves examining all that is expected of the students by teachers, parents and institutions.

Variables in Mastery Learning

Over the past fifty plus years our schools have proceeded on the assumption that there is a standard classroom situation that works for all students. This assumption appears to have regained popularity in the nineties, as emphasis is placed again on standardized curriculum, national standards and accountability. The search for just the right standards, instructional methods, materials, curriculum and teachers has been relentless.

> As we approach the new millennium in our increasingly culturally diverse society, educators must start with a very different assumption: individual students may need very different types and qualities of instruction to achieve mastery. For centuries educators of eminence have recognized this assumption (Benjamin Bloom, 1968). Yet, Even in an educational textbook Foundations of Education by Ornstein/Levine published in 1993, "mastery learning" or "Learning for Mastery"(LFM) is a widely used approach that was originally associated with John B.

Carroll (1963) and later (1968) with Benjamin Bloom. It is still used widely in public schools (Ornstein, 1994, p. 547). The Mastery Learning Model operates under the assumption that despite individual differences in learners if students are normally distributed by ability or aptitude and are provided with adequate instruction, materials and time matched to their individual characteristics ninety per cent will achieve mastery of a given subject (Carroll, 1963). Carroll also contends that if a student does not spend enough time to learn a task, he or she will not master it. If the above mentioned research based and time-tested assumptions are true, then the key variables and optimum learning conditions can be identified.

These key conditions appear to be: student characteristics: (aptitude, learning style or preference, perseverance/time on task); and teacher controlled variables (quality of instruction, knowledge of curriculum, concept or skill, specific objectives, task analysis, and time allowed for learning evaluation).

Student Characteristics

Starting with the student characteristics, a study by Benjamin Bloom (1968) of aptitude distribution relative to student performance shows that there is a continuum of abilities. At the top of the aptitude distribution (1 percent to 5 percent) there are some students who have special talent or ability for a subject or skill. Whether this is a result of inborn ability or the effect of previous training (nature vs. nurture) is not clear. At the other extreme of the aptitude distribution, these are students with special disabilities for a particular subject or skill. Again, it is believed that these contribute less then 5 percent of the distribution (Bloom, 1968). Bloom, who is well known for his "taxonomy" contends that:

> Ninety percent of public school students can learn . . . although slower students require a longer period of time to learn . . . if their initial level of knowledge is correctly diagnosed and if they are taught with appropriate methods and materials in a sequential manner(Ornstein/Levine, 1994 p. 548).

From a socio-cultural perspective on learning detailed in Vygotsky's Mind in Society (1978)it is suggested that tasks that a child is expected to learn be presented within his or her "zone of proximal development" or "tasks that the child can perform only with assistance." According to Vygotsky:

> There are individual differences in widths of Students' zones with more capable students having wider Zones than do less capable students. That is, to perform tasks similar to tasks they have already mastered, more capable students require less prompting

then do less capable students.

Students should not be viewed as able or unable to learn, but should be viewed in terms of the amount of support individual students may require to learn a given concept or skill(Pressley, 1964). In other words, it is possible to teach to mastery the more difficult of the multiplication facts presented in this project providing that these variables of additional time and support are taken into account in the design of the project.

Next an exploration of student characteristics and a discussion of learning style/preferences is in order. Individuals have preferred ways of learning and interacting with the environments. Various educational theorists have acknowledged preferred ways, or styles, of learning for many decades. As early as 1912 Maria Montessori, an internationally known Italian scholar, was convinced that the "teacher must consider the child completely . . ." Montessori serves as a reminder that successful educational pedagogical practices have for decades made use of tactile and visual- motor activities. These activities have been recognized in many developmental theories (Gaddes, 1991). Likewise, Piaget (1956) drew attention to integrative perceptual and conceptual processes in cognition. He theorized the child from seven to eleven years of age was in the concrete operational stage. In this stage they need to manipulate objects in their environment and experience the objects with as many of their senses as possible to successfully learn concepts such as conservation.

More recently, modern research in brain function sheds light on how the brain integrates visual, auditory and motor pathways throughout the brain. Recent research in neurosciences shows that the human brain has within it a wide array of ways to process experience (Samples,1987).

> Learning modalities, which are dominantly biological, are based in part on sensory input and specific design features of the brain. Each person develops preferences among sensory modes favored for learning. For example, a student with visual-spatial preferences will tend to rely on sight as a favored sense for accessing information and experience. Students with an auditory preference will tend to focus on hearing and the patterning of sound. Kinesthetic students will seek out learning that focuses on touch, movement and full body participation (Samples, 1994, p.15).

All of this research, also, has profound educational implications for the nature of learning and attention, memory and motivation to learn. A patterned intentional diversity in instruction creates an educational environment that provides both a cognitive and affective base for learning (Samples, 1994). We can now let the knowledge of brain structure direct us in finding effective remediation (Gaddes, 1994).

Another way of looking at the assumption that individuals have preferred ways of learning is through the work of Keith Golay in Learning Patterns & Temperament Styles (1982). This educator explains that all human behavior is purposive. As time passes the personality becomes more complex. The personality gives direction to the growth, learning and development of the individual throughout life (Golay, 1982). Golay based much of his work on Kiersey's work in Please Understand Me (1978). Keirsey identifies four basic personality or temperament styles. Each type displays patterns of thinking and desiring underlying and giving rise to behaviors that are constant. According to Keirsey, the four basic temperament styles are: Dionysian Temperament (core value - freedom), Epimethean Temperament (core value - duty), Promethean Temperament (core value - competence) and Apollonian Temperament (core value -discovery of self). It is important for educators to consider personality type in planning for instruction. The importance of understanding and valuing differing temperaments is in the theory that each of these different temperament styles has an accompanying different learning style or preference. For example, an instructor can best reach the Dionysian student with projects (construction/operation), contests, games, dialogue and by offering choice or variety in their classroom environments. The Epimethean student can best be reached in a very structured and predicable classroom environment that focuses on lecture, demonstration, drill, homework, questions/answers, and tests. The Promethean student thrives on lecture, composition, designing, creating and projects. The Apollonian student, on the other hand, works best when the instructional setting allows for personal interaction, drama, discussions and dialogue and the democratic process. An instructor that has a variety of strategies is more likely to help more of his students achieve mastery of a concept or skill (Golay, 1982).

Howard Gardner, in his book Frames of Mind (1983), in an effort to broaden the scope of human potential beyond the I.Q. score, brought forth theories about learning styles or preferences and referred to them as "multiple intelligences." He described the broad range of abilities that human beings possess and defined seven categories or intelligences. The seven categories are: linguistic learner, logical-mathematical learner, bodily-kinesthetic learner, spatial learner, musical learner, inter and intra-personal learners. Proponents of the multiple intelligence theory believe that each child possesses all seven of the intelligence. The child's preference to use some of these intelligences over others is viewed by some learning theorists as being the child's learning strength. Thus, Gardner, too, recognized and appreciated the variety of ways that instructors could best assist a larger number of students.

Another factor under student characteristics that affects mastery learning, is that of motivation. For the scope of this project, it is important to recognize that because the at-risk learner will be asked to master skills that have, in the past, been difficult for him or her, the student will need to be motivated. Carroll (1963) defines "perseverance" as the time the learner is willing to spend learning. This is, also, sometimes, referred to as "motivation". While efforts are being made to increase the amount of perseverance in students or to "motivate" them, it is likely that control of the instruction and learning materials may be the most effective way of helping students achieve mastery. It has been shown that frequency of reward and evidence of success in learning will increase students' perseverance in a given learning situation. There is a growing consensus among motivation theorists and researchers that praise and reinforcing students for progress will result in a greater commitment to learning and achievement (Pressley, 1996). Other specific research find that at-risk students are threatened by academic tasks and a reward, or a promise of a reward deflects their attention from the fear and anxiety they feel when asked to complete a specific task that propels them to act and approach learning. Many at-risk students lack purpose or the desire to excel. Strong positive verbal (print or graphic) interaction in the form of praise and encouragement may be more effective than tangible rewards with some of these students. The remedial procedure attempted in this project is a "success model" of learning which implies that a desire to learn must precede learning (Gaddes, 1994). Praise and reward are built into the project to encourage the students' perseverance.

Teacher Controlled Variables

In designing this project it has been important to keep sound educational practices in focus and to incorporate them into the design.

According to Bloom (1974), it is highly probable that more effective learning conditions, or quality of instruction, can reduce the amount of time required to learn a subject or skill to mastery level. In the day to day classroom environment, the students' abilities and characteristics interact with the instructors' abilities, training, style and characteristics. Because of this assumption, it becomes necessary to examine some of the teacher-controlled variables in learning. For example, the greatest payoff for a teacher in dealing with students varying abilities to understand instruction is likely to come from the teacher's creativity in modifications in the instruction in order to meet the needs of individual students. Given proper training and various aids, teachers can find ways of modifying their instruction to fit the needs of their students. Varying types of materials (textbooks, workbooks, audio-visual methods and academic games are just a few), serves as a means of helping individual students at selected points in the learning process. These are examples of attempts to improve quality of instruction in relation to the ability of each student to understand instruction (Bloom, 1968). Most important, the knowledge of the great variety of instruction materials and strategies should help both teachers and students to overcome "feelings of defeatism and passivity " about learning (Bloom, 1978, p.27).

According to the 1994 California Department of Education Publication, I Can Learn, some of the general strategies for facilitating instruction delivery are:

1. The teacher must have a thorough knowledge of the curriculum, concept or skill that he or she is teaching.
2. The teacher must complete a task analysis of the skills needed to learn the new concept or skill.

3. The teacher must present each concept or skill singularly and sequentially.
4. The teacher must assess often to determine the students' mastery (this will pinpoint any breakdown in comprehension or mastery).
5. The teacher must relate new concepts to the student background, experience and interest.
6. The teacher must clarify intended outcomes to the students.
7. The teacher must review frequently and integrate new material with previously presented concepts and facilitate transfer.
8. The teacher must use simultaneous, multisensory instructional strategies that combine visual, auditory and kinesthetic presentations.
9. The teacher must use graphic displays to help students organize newly presented concepts or skills.
10. The teacher must allow sufficient time and rehearsal.
11. The teacher must use computer technology to individualize instruction, create individual material, to provide multisensory instruction and to increase student motivation.

How Students Learn

Teachers cannot simply wish or hope that their students will learn. In addition to having a wide arsenal of learning strategies at their disposal, teachers should know how the learning process works and they should know the role that cognitive skills play in the process. If the student is having difficulty in retaining the concept or skill, the teacher should be able to access various research based principles and/or strategies that would be appropriate for the task required. For example, Maria Almendarez Barron in "Surprising Truths: The Implications of Brain Research" (1997) has found that children who can learn from flashcards will learn better if the card is round. Students have a role in the learning process too. They must make a conscious decision to "attend" to the concept or skill being presented. Once they have made that decision, a system for processing is activated. This system requires steps or phases that will affect the degree to which the concept or skill is learned. According to Charles A. Letteri in his journal article "An Introduction to Information Processing, Cognitive Controls and Cognitive Profiles," "Cognitive style" is how students learn. "Cognitive control" is what students do to direct and control the learning process.

In the first phase, students gain information through sensory receptors: eyes, ears, skin, tongue and nose. The second phase requires a screening or a filtering by the visual and auditory centers of the brain. This screening or filtering process determines whether the information is old or new and it provides a basis for decision making about the next phases in the processing of the information. In the third phase, the student must now direct attention to the specific concept or skill to be learned. Learners must want to learn the concept or skill presented and they must also begin to use their cognitive skills to assist in information processing. In the fourth phase, information is maintained in the short-term memory while working memory applies appropriate strategy for learning to begin (Foriska, 1993). The fifth phase, working memory, is also considered a part of short-term memory. It connects appropriate cognitive operations and long-term structures. During the operation of the working memory, students use sequential processing skills to "integrate the learning by steps or as a holistic experience." Memory skill is also used to retain a distinct image of the new concept or skill). In the final phase of the processing, the long-term memory holds all the information (be it concept or skill) that has been learned. This new concept or skill can be accessed as needed. Categorization, spatial and memory skills are crucial to access or retrieval from long term memory (Letteri, 1988).

These relatively recent findings by cognitive researchers have important implications for instruction. From the teachers' point of view the learning process begins with students taking data from the environment mainly through sight. Logically then, teachers should use visual resources in the classroom. During the screening or filtering process, therefore, an important instructional component at this junction is for the teacher to "connect the new learning to that which has been previously learned and that which will be learned in the future. The key is the ability to make the connection in a way that sparks students' interest"(Foriska, 1993). Some effective methods for maintaining information, concepts or skills include the use of visual strategies, the use of rehearsal strategies, elaboration strategies, organizational strategies or mnemonic strategies. Visual strategies might include the use of diagrams, pictures, graphs, mind maps, etc. Rehearsal includes encouraging students to rehearse stimuli visually and/or verbally) or in writing. Elaboration includes using elements of stimuli and assign meaning to it (i.e. "Every Good Boy Does Fine" is an elaboration for remembering the lines of the treble clef in music) (Gaddes, 1994). One example of how organizational strategies might work is to demonstrate to students how specific learning tasks can be grouped by common attributes.

In other words, the information, concept or skill to be learned is finally moved to long-term memory by "overlearning" or by increasing the "meaningfulness" of the material to the learner. Teachers can help facilitate their students' learning by utilizing and modeling techniques for storing information through rehearsal, organizational, elaboration strategies organizational, and mnmemonic strategies.

Impact of Technology

Lewis, et al. (1987) and Lewis (1993) have researched the various benefits of technology for young students with disabilities. Their findings could also apply to the broader category of at-risk students as well. Some advantages are:

- Technology is a strong motivator
- Technology can produce improvement in student academic performance
- Technology can create opportunities for practice that are often unavailable to learners with difficulties
- Technology acts as a catalyst for improving students' self-esteem and self-concept
- Technology can add to the perception of at-risk students being more able as learners

In addition, computers provide immediate feedback with the intended motivational advantages. Computers, also, mix visual activity and listening modes of learning as they offer a non-judgmental, private environment in which students can test their own thinking and memory at their own speed (Duttweiler, 1992). The uniqueness of the computer as an educational tool enables at-risk students to venture into the area of new area of concept or skill acquisition with minimum risk of failure. The computer offers motivation, self-pacing and privacy (Scott, Kahlich & Barker, 1994). Such advantages and benefits of technology was the impetus guiding my decision to develop this project.

What the Research says about Multimedia

Over the past two decades researchers have repeatedly identified two variables as critical to the success or failure of technology (including multimedia) in our schools. The first variable is that of product design and the second is of teacher effectiveness and training.

Because recent cognitive research shows that children learn better actively, non linearly, visually and cooperatively, the software publishing industry is making great efforts to deliver software designed with these models in mind. Computer based multimedia now provides a great diversity (Cannings & Finkel, 1993). New products are being marketed daily. It is imperative that we not become victims of "multimedia mediocrity" (Sponder & Hilgenfeld, 1994). This happens when software designers, be they professional or teachers, lack direction in their design. If we plan to use multimedia in our products we must pay attention to educational relevance and design.

The Center for Technology in Education concluded in

1989 "learning is an active, constructive process, in which the developments of content knowledge and cognitive skills are integrally related." This research on multimedia lead me to the following more recent research on multimedia's impact on education as cited by M.D. Roblyer (1999).

Research he examined was conducted by S. Bagui and the research studies pointed toward the benefits that multimedia offers to the learning process. Bagui (1998) acknowledges that multimedia is a unique asset to learning because of its ability to "store, interconnect and provide access to a wide range of knowledge"(p.16). He summarizes that multimedia may aid in learning because it parallels the natural way people learn.

Bagui (1998) finds that, according to "dual coding theory (or learning through more than one channel) increases a person's usable knowledge base." Bagui believes that this "helps reduce cognitive load… and increases what people can remember and bring to bear on other learning"(p.16). Bagui also explains that the brain does not usually work in a linear fashion, but more like a fishnet. Because multimedia can be organized parallel to this structure, people have more control of direction and pace of their own learning.

In my opinion, Howard Gardner supported these general theories as well, but Gardner explained them in different terminology focusing on the "Theory of Multiple Intelligences.'

Finally, Bagui (1998) found that "chunking is extremely important to current learning theory. People can hold five to seven items or chunks of information. This is why telephone numbers are segmented the way that they are. Multimedia presentations can, also, allow for chunking of information, which ultimately puts less pressure on short-term memories and aids attention.

Like Bagui and Gardner, L. Stemler (1997) finds that the effects of any given multimedia product depend on how well it is designed and delivered. Stemler contends "a medium is only as good as its content. Stemler finds the optimal characteristics that shape effective screen design: the screen design itself, learner control and navigation, feedback and interactivity as related to navigation.

Learning with multimedia is viewed as an active, constructive process whereby the learner strategically manages the available cognitive resources to create (new to the learner) by extracting information from the environment and integrating it with information already stored in memory (Kozma, 1991). Many educators are finding that a multimedia approach is effective especially with at-risk students. The realistic graphics and sounds offered by videotapes, laser disks (and now CD's and DVD's) can be important aids for students who lack basic reading skills. In my opinion, even at-risk students are coming to us with an increased visual literacy. They have been reared watching television shows, videotapes, rock videos and movies. Video based lessons captured through multimedia are one way of gaining the interest and attention of our young people, some of whom have been turned off to school (Cannings & Finkel, 1993).

Conclusion

In conclusion, teachers, software designers and others involved in imparting knowledge or skills should know their learners' characteristics, know how the learning process works, know motivation theory and have a repertoire of instructionally sound strategies. This review of literature has had an important impact on the final outcome of the project that I have designed to help students memorize the more difficult of the multiplication facts. Thus, I decided to include multimedia in my project.

CHAPTER THREE

Goals and Objectives

A major problem facing many teachers of at-risk students in elementary school is how to motivate them. The purpose of this master's project was two-fold: 1) the intention is to provide at-risk students with a computer-based multimedia program to motivate them to continue to try to learn their multiplication tables to mastery.
2) It was the intent of the project to present different cognitive strategies that will enable them to commit the more difficult of the multiplication facts to long term memory. Multimedia systems utilize interactive media technologies that combine, deliver, and transform information by means of images, video, audio, animation and text. The goal of the program was to develop a software program that utilized some of the current technological resources to augment traditional textbooks used in the core curriculum. This program would also supplement traditional teacher directed presentation of the multiplication tables. The uniqueness of this software program is that its approach was designed to utilize cognitive strategies (visual/auditory/sensory-motor/musical) at Bloom's "knowledge' level of learning.

According to Gaddes (1994) current evidence from cognitive psychology suggests that learning is an active, constructive process whereby the learner strategically manages the available cognitive resources to create a new knowledge already stored in long term memory. Consequently, a learner's current understanding (or prior knowledge) plays a role in the new learning. The content of this knowledge and how it is structured, organized and represented in memory has a bearing on the outcome of the learning process (Kozma & Cronninger, 1992). It is anticipated that at-risk student's motivation levels will be elevated as they use this environment enriched with multimedia as they continue their struggle to memorize the more difficult of the multiplication facts. With the dynamics of the software, students will be engaged in their own learning. Thus, it is hoped that the students will be empowered by having a chance to operate the program on their own (Kinnaman, 1993). The students should become motivated with the use of this program and its dynamics, and in turn will organize visual, auditory and musical images and thus more able to store the facts in their long term memories for easy access and retrieval.

Goals

I call this project "Memory Magic for the Multiplication Monsters" focusing on the six, seven, eight and nine facts. I intend to provide this computer based instructional tool to present to a whole group or to students who could work alone or in pairs independent of the instructor. From experience I know that that this instructional design of combining visual, motor, auditory and musical strategies works when it is teacher directed and presented in small groups. Knowing that I have a finite number of students that I can personally reach with these strategies through my resource room and through my collaborative attempts each year, I would like to make these strategies available to more students, teachers, and parents. It is the intent of this designer that students using this piece of software will be able to commit to memory the "chunked" (Bagui, 1998) multiplication facts in the six, seven, eight and nine clusters employing these easily remembered visual, auditory, motor and musical strategies.

Learners

In the area of any of the five kinds of learning capabilities (intellectual skill, verbal information skill, cognitive strategy, motor skill or attitude), the students enrolled in any given California public school would fall along a continuum ranging from "little capability" through "exceptional capability." The remedial students who would be most likely to use this project could also fall anywhere along this continuum. Students that I have personally instructed in these strategies have ranged from low average cognitive ability to above average cognitive ability. Some of the learners have been labeled "Learning Handicapped" [(LH) for example, my resource students], while others have been labeled "English Language Learners (ELL) who are also referred to as English as a Second Language Learners (ESL). Most of the students that I have used these strategies with have been considered at-risk.

The learners that will be most successful using this project are school age children between the grades of five to eight (corresponding to the ages of 10 to thirteen). In my opinion, these learners need to be developmentally mature enough to visually image (Piaget, 1970). They must have some basic language skills. The learners must already possess the essential prerequisite skill of forming sentences. The learners need to possess an adequate working memory (where to-be-learned material is taken in and processed for memory storage). The contents of long term memory (prior knowledge) must be retrievable to the working memory. For example, in the case of this project's essential prerequisites, these learners will have already memorized the multiplication facts clustered in the zeros, ones, twos, fives, and tens. This project will be of most benefit to learners who have adequate (or better) visual/auditory processing and visual/auditory memories. "When a search of memory makes contact with a single sentence, other interconnected sentences are brought to mind. This process is known as the *spread of activation* and is considered to be the basis for retrieval" (Gagne, 1992). This spread of activation theory is especially important to the strategies presented in this project. Thus, students who engage one or more of the following multiple intelligences: linguistic, spatial, bodily kinesthetic and/or musical (Gardner, 1985) are bound to be successful using these strategies. Likewise, students whose learning style strengths are visual, auditory, motor or any combination of these, will likely experience success with these strategies. Students with an "external locus of control" and who are being "encouraged" to build their skill in multiplication will appreciate the structure built into the project. Students with an "internal locus of control" and who are pushing themselves to memorize the multiplication facts will find the flexibility built into the project useful to their goals of self-improvement.

Specific Instructional Objectives

The learner will select and adopt one (or more) of the strategies presented by this project to facilitate his or her task of memorizing the products of the multiplication facts. Depending on the strategy adopted, one (or more) of the following instructional objectives would apply.

1. Given ten (or more) problems containing the nines times facts with the product to be memorized, the student will adopt the strategy of folding down the numbered finger that represents the multiplier of the nine. S/he will count the finger/s to the left of the folded finger by tens and write it in the tens place for the product. S/he will count the fingers to the right of the folded finger by ones and write that number in the ones place. The student will retain this strategy for two months (or longer) and the transfer of these facts and their products to long term memory as demonstrated

by achieving 70% (or higher) on monthly timed tests of these facts.

2. Given ten (or more) problems containing the times facts with both multipliers consisting of digits of six or greater, the student will adopt the strategy of using hand symbols with a specific fingers representing each of the numbers from six through nine. To compute the product the student will first multiply the folded fingers on each hand together. This digit will be written in the ones position of the product. Then s/he will count the fingers standing up (unfolded) by tens and write that number in the tens place of the product. The student will retain this strategy for two months (or longer) and the transfer of these facts and their products to long term memory as demonstrated by achieving 70% (or higher) on monthly timed tests of these facts.
3. Given ten (or more) problems containing the nines times tables with the products to be memorized, the student will adopt the strategy of applying the knowledge that the sum of the digits in products of the nines is nine. This technique will be demonstrated and practiced. One will be taken away

from the multiplier. The student will write the digit in the tens place of the product for the nines fact. S/he will next find the missing addend that would make the product add to nine for in order to supply the number that belongs in the ones place of the product. The student will retain this strategy for two months (or longer) and the transfer of these facts and their products to long term memory as demonstrated by achieving 70% (or higher) on monthly timed tests of these facts.

4. Given ten (or more) problems containing the seven and eight multiplication facts with their products to be memorized, the student will adopt the visual - key story strategy. The student will be presented with key stories to facilitate memorization of the products. The "seven" key stories will involve "Party Stories" and the "eight" key stories will involve "Snowmen Stories." The student will retain this strategy for two months (or longer) and the transfer of these facts and their products to long term memory as demonstrated by achieving 70% (or higher) on monthly timed tests of these facts.

5. Given ten (or more) problems containing the six multiplication facts with their products to be memorized, the student will adopt the auditory "Rap" memory technique (musical). The student will be presented with musical raps for the more difficult products of the sixes. The student will retain this strategy for two months (or longer) and the transfer of these facts and their products to long term memory as demonstrated by achieving 70% (or higher) on monthly timed tests of these facts.

Chapter Four

Project Design and Development

The research findings support that the effectiveness of any given multimedia project depends on how well the project is designed and delivered (Stemler, 1997). In keeping with these findings, careful consideration was placed on the functionality and usability of this project (Kristof, 1995).

It is extremely important in the design of any project to begin with organization. Organizing content was the first of many inter-related steps. For example, realistic planning was dependent upon decisions about scope and complexity of this particular program. Decisions about the authoring tool to be selected and the delivery system had to be made. The audience needed to be defined (i.e. Who will use it and how?).

This chapter describes the content area for which the project was designed, the characteristics of the project, the technological requirements, the audience, and specific goals and objectives. There will be a focus on project design and development. The formative evaluation will be discussed in relation to the strengths and limitations of the project. Future recommendations are given based on the formative evaluations.

Content Area

The project and accompanying HyperStudio inter-related stacks are titled "Memory Magic for the Multiplication Monsters." This project involves the design and development of computer based instruction material that can be used in conjunction with the core curriculum of any mathematics classroom. The purpose of this project is to develop a computer based program to motivate at-risk students to learn to the mastery stage the more difficult (6's, 7's, 8's and 9's) of the multiplication facts.

Characteristics

This program, via HyperStudio stacks, uniquely presents the more difficult of the multiplication facts utilizing visual, auditory, motor and musical memory strategies, interwoven with guided practice and game-like activities.

Technical Requirements

To run this program designed for HyperStudio, one must own a personal computer and the software HyperStudio (Mac or Windows). The minimum requirements are for the computer to have at least a 386 processor that runs Windows 3.1 (or higher) and 4 MB of RAM (8MB preferred). The video adapter must be capable of displaying 256 colors. A Sound Blaster or Windows Sound System sound card is necessary to utilize the sound capabilities of HyperStudio. A CD-ROM drive and access to the internet would be beneficial in order to take advantage of all of the project's buttons (Wagner, 1997).

Audience

In the area of any of the five kinds of learned capabilities: intellectual skill, verbal information skill, cognitive skill, cognitive strategy, motor skill or attitude (Gagne, 1992), the students enrolled in any given California public school would fall along a continuum ranging from "little capability" through "exceptional capability." The at- risk population of learners that this program was designed for could fall anywhere along this continuum. Students that I have personally instructed in these strategies have ranged from low average to average cognitive ability. These students have been labeled "at-risk" regular students, "Learning Handicapped" (LH-resource students), while others have been labeled as "English Language Learners" (ELL) or alternately, "English as a Second Language Learners" (ESL).

In my estimation the students that will be most successful using this project are elementary or middle school students between the grades of five and eight (ages approximately ten to fourteen). These students need to be developmentally mature enough to "visually image"(Piaget, 1970).

They must have some basic language skills (the ability to form sentences). They also need to possess an adequate working memory (where to-be-learned material is taken and processed for memory storage). There are some other supportive prerequisites. One would be an adequate command of verbal information (i.e. the ability to recognize and recall short, two to three sentence, stories paired with visual images). Another prerequisite would be that the student should have an external or internal locus of control. Either of these controls would function to motivate the students to memorize these more difficult of the multiplication facts (Gagne, 1992). Some knowledge of HyperStudio navigation would be helpful, but not mandatory.

Project Design

The medium of delivery chosen for the design of this project was HyperStudio. This medium was selected because it is familiar software to both teachers and students. This software is currently readily available in most public school computer labs (Kristof, 1995). It is relatively simple to use as an authoring tool.

This project attempts to teach to mastery level specific strategies (Bloom, 1968). The project's intended learning outcome is to encourage at-risk students to adopt those learned cognitive strategies. In keeping with Gaddes' discussion of the "success model" in 1994, the intended goal of this project was a success model of learning. Thus, each card in the stack was created with design and motivational principles in mind. Each card or activity supports either the acquisition and/or the retention of a particular concept or product of a multiplication fact.

As was presented in the Review of the Literature section of this paper, recent cognitive research has stated that "the children who can learn with flashcard will learn better if the card is round (Baron, 1997, p.1). Since the circle is the first shape learned at the developmental age of three, circular cards generally allow children to focus more strongly on the content of the flashcard. This round shape is the least distracting. Therefore, whenever possible, concepts and important cards were designed with circular effects (Figure 1).

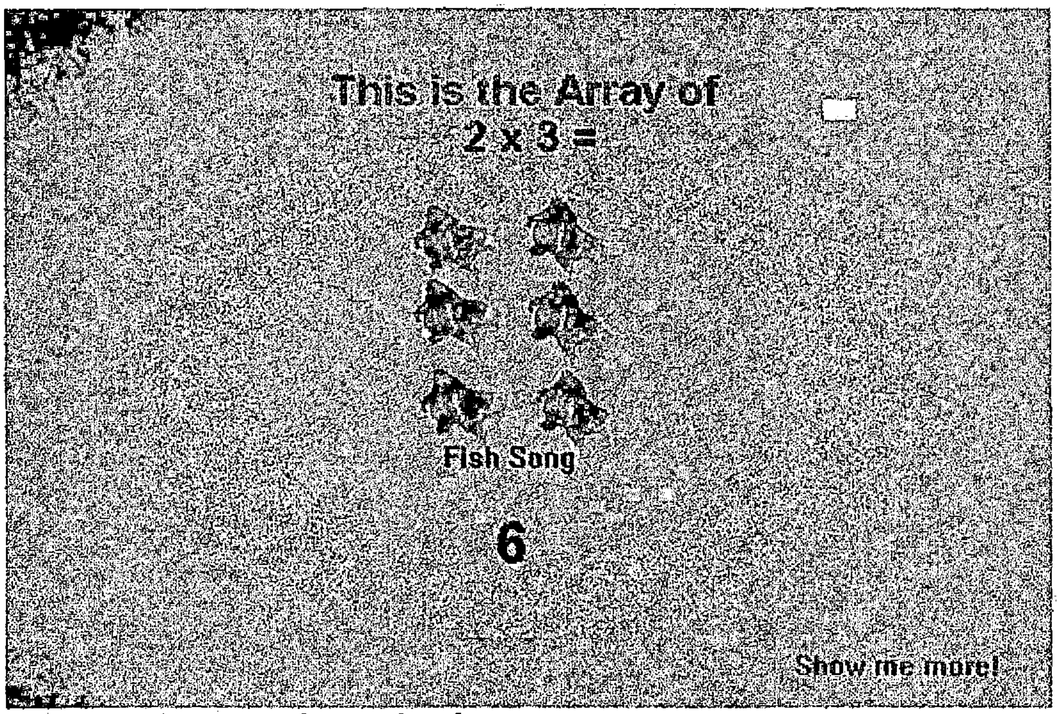

Figure 1. Round Cards for Concepts

The background colors were chosen based on instructional design principles. For example, artists have long appreciated that blue, green and violet are "cool" colors. Heinich (1996) suggests choosing cool colors for backgrounds. Cool colors were selected for use with this project.

Using the design principles for ensuring legibility, increasing engagement, focussing attention and reducing effort, in the design of this project an effort has been made to balance visual and verbal elements. Heinich (1996) recommends the use of no more than two type styles in a series of related visuals. This principle was adhered to in the design of this project. The Ariel typestyle was chosen because of its similarity to print found in many texts and because of its legibility. Schoolboy typestyle was occasionally used for emphasis and to focus attention. Color was used for Figure ground contrast and carefully considered before it was applied. Concepts and ideas that needed emphasis were occasionally given warmer hues. For the same purpose, the size of the lettering was sometimes deliberately manipulated (Figure 2).

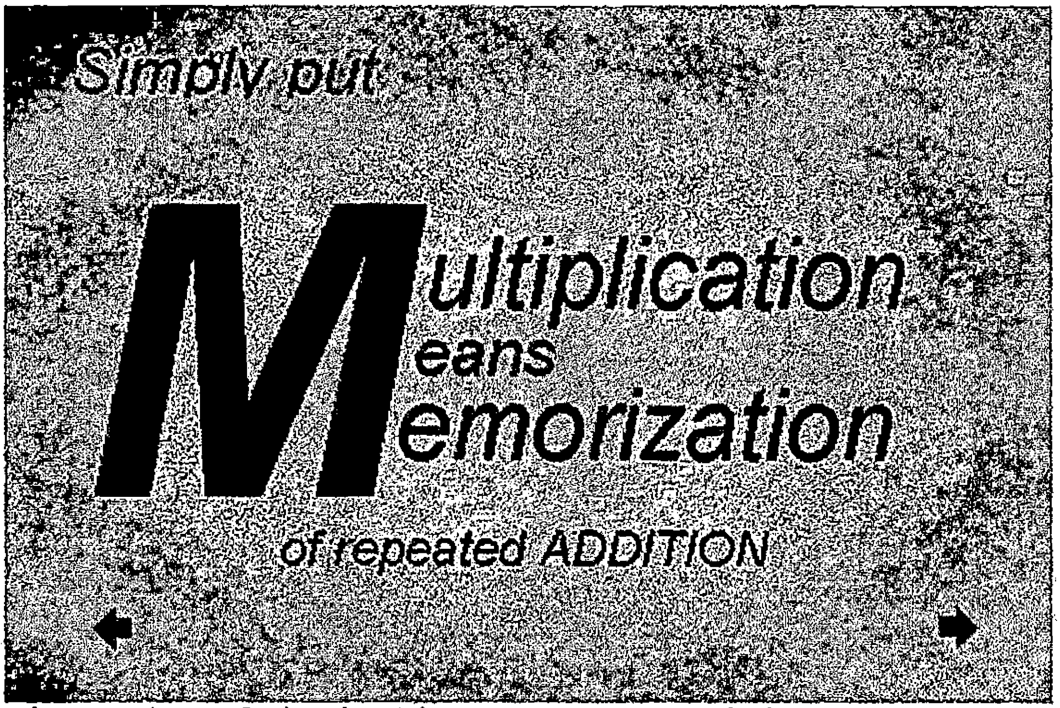

Figure 2. Multiplication Repeated Addition

In keeping with the 1994 research from the California Department of Education that supports informing the learner of the objectives, a few cards were designed as direct communication with the learners. The intended purpose of this project was to present several instructional strategies in a multi-modal format that would aid the process of learning the more difficult of the multiplication facts. My first task was to gain the student's attention and cooperation. In the home stack a card was designed and presented to offer this direct communication and clearly state the goal in language that the students could understand (Figure 3).

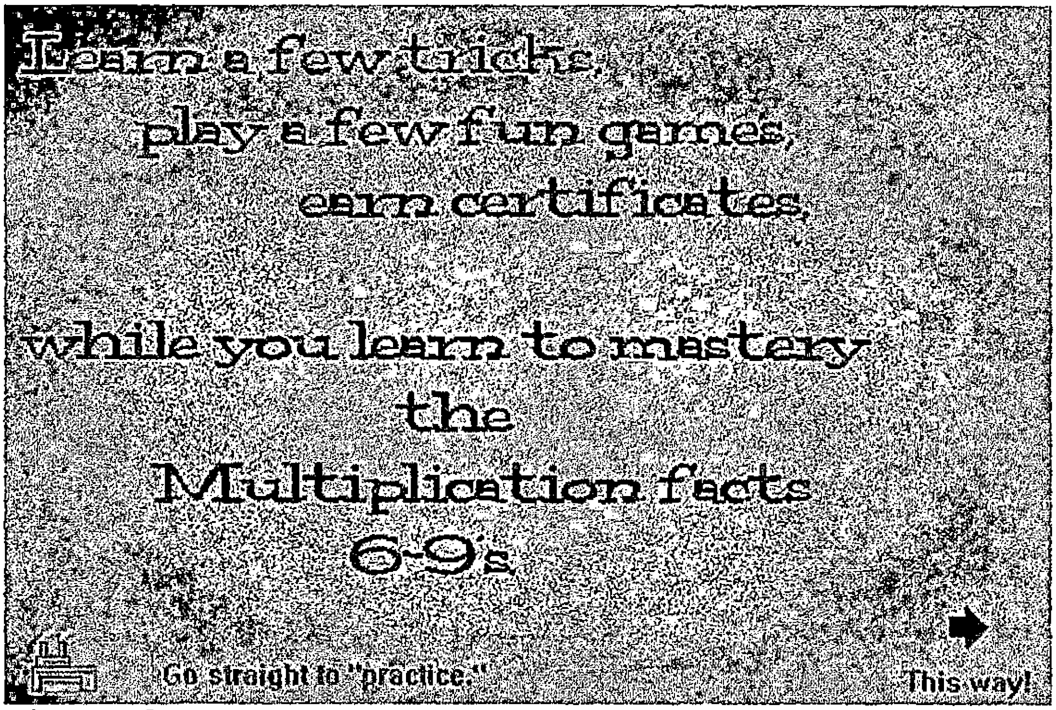

Figure 3. Reasons to Learn

Researchers studying the impact of different psychological traits on learning have reached the conclusion that students' prior knowledge of a particular subject influences how and what he or she can learn more than does the psychological trait (Gardner, 1993).

In keeping with this research-based assumption the students were reminded that they had already had some success in learning some specific multiplication facts (Figure 4).

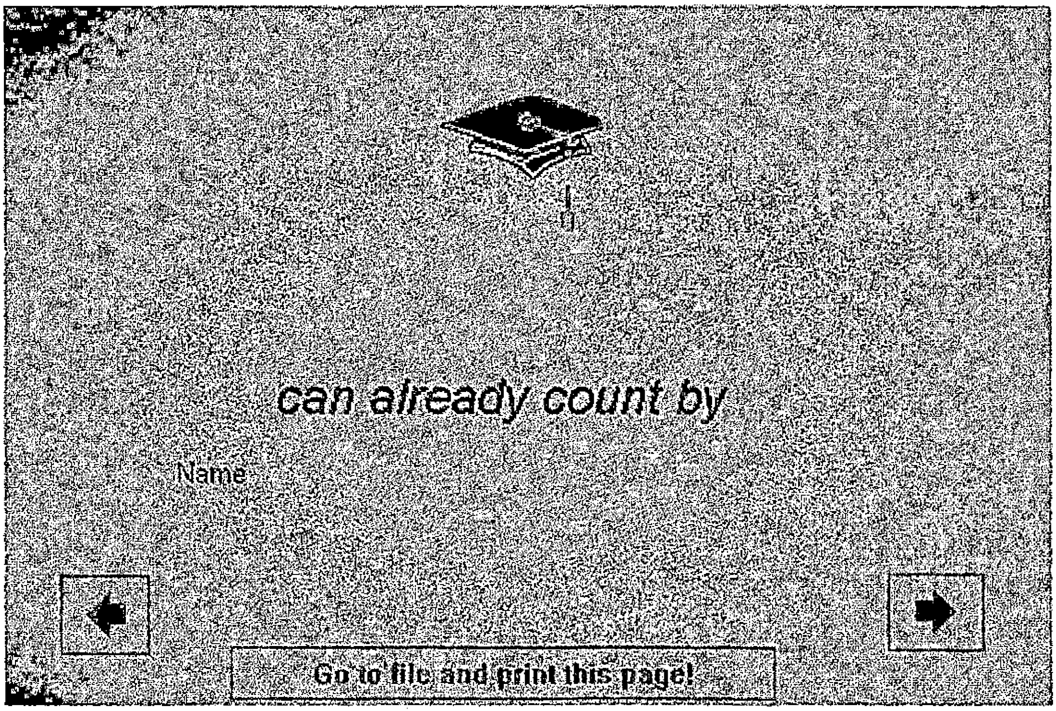

Figure 4. Congratulations Card

The presentation cards, tasks and activities were intended to stimulate the students' "receptors" to produce patterns of neural activity that are . . . 'registered' by sensory registers. This information is later changed into a meaningful form that is recorded in the "short term memory" (Gagne, 1992). For this reason the multiplication facts have been "chunked" into meaningful cartoon stories (Figure 6, the 8's), finger tricks (Figure 5, the

6 through 9's), musical presentation cards (Figure 6) and predictable patterns (Figure 7, the 9's). The chunking of the strategies then have an increased chance of entering long term memory for storage (Bagui 1998).

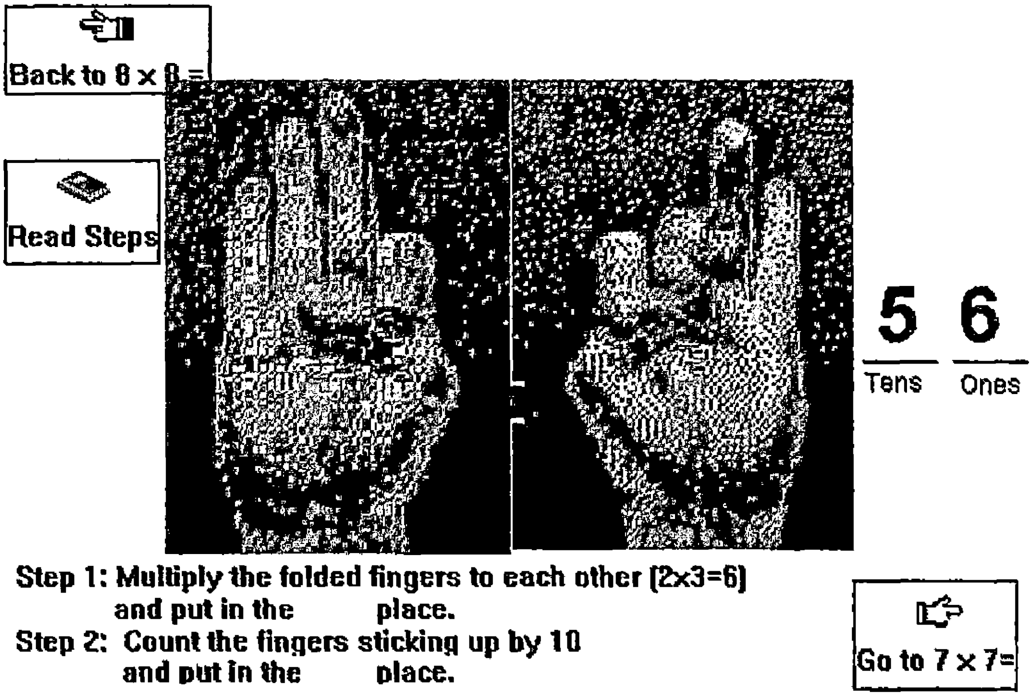

Figure 5. Example Finger Trick

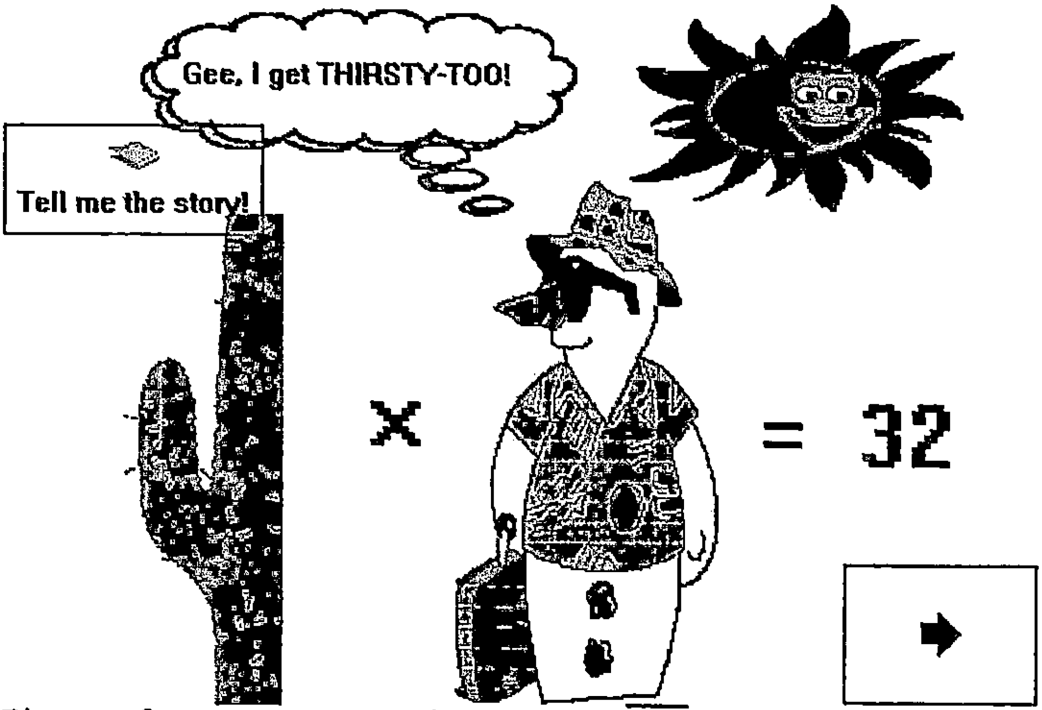

Figure 6. Snowman Stories

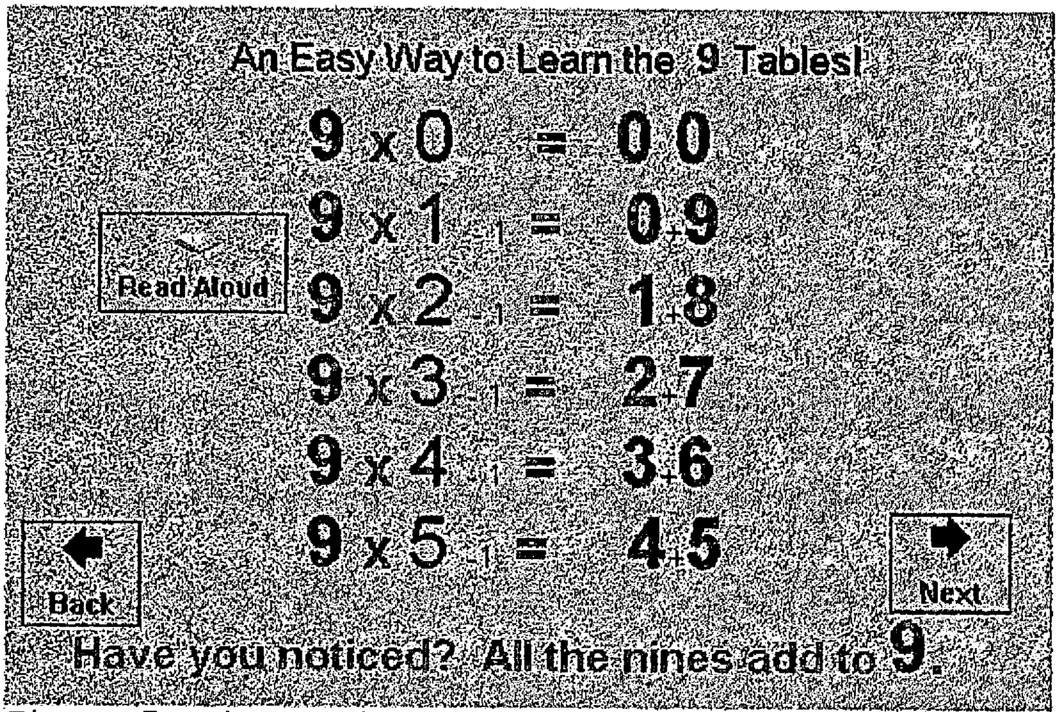

Figure 7. Nines Trick

Evidence of adoption of these strategies will be demonstrated as the students engage in guided practice tasks. The students are guided to print pages of practice problems. They are encouraged to complete the problems and turn them in for evaluation by the teacher. These activities are intended to provide students with guided practice and, hopefully, with immediate feedback from their teachers. Hornbeck in 1990 discussed the importance of prompt feedback by way of computers. In keeping with his ideas this project was designed with a system for guided practice and the added advantage of teacher/student interactions (Figure 8).

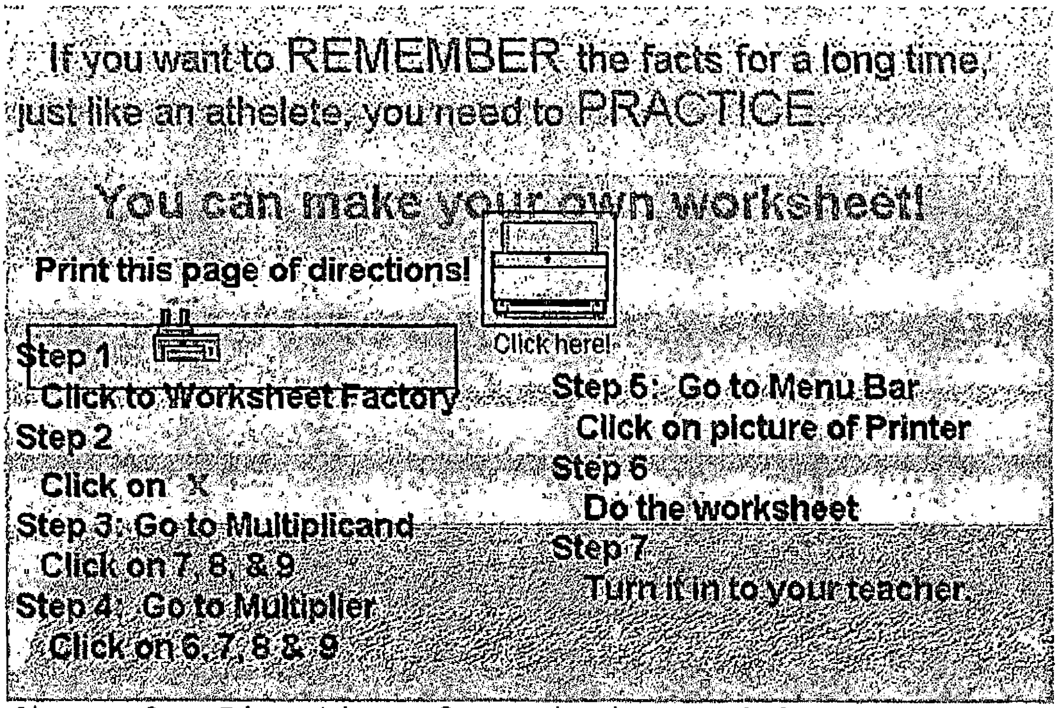

Figure 8. Directions for Printing Worksheet

The card in Figure 8 demonstrates another important variable in student learning. This is one of the features in the project that was designed to allow for "executive control" (Gagne 1992). Allowing the students to follow the steps necessary to print their own worksheets empowers the students to become more independent learners.

It was intended that these provisions (Figure 9) offered in this project for "practiced retrieval" described by Gagne in 1992 include both the guided practice described above and motivational games (Figures 9 and 10).

Figure 9. Games as Motivators

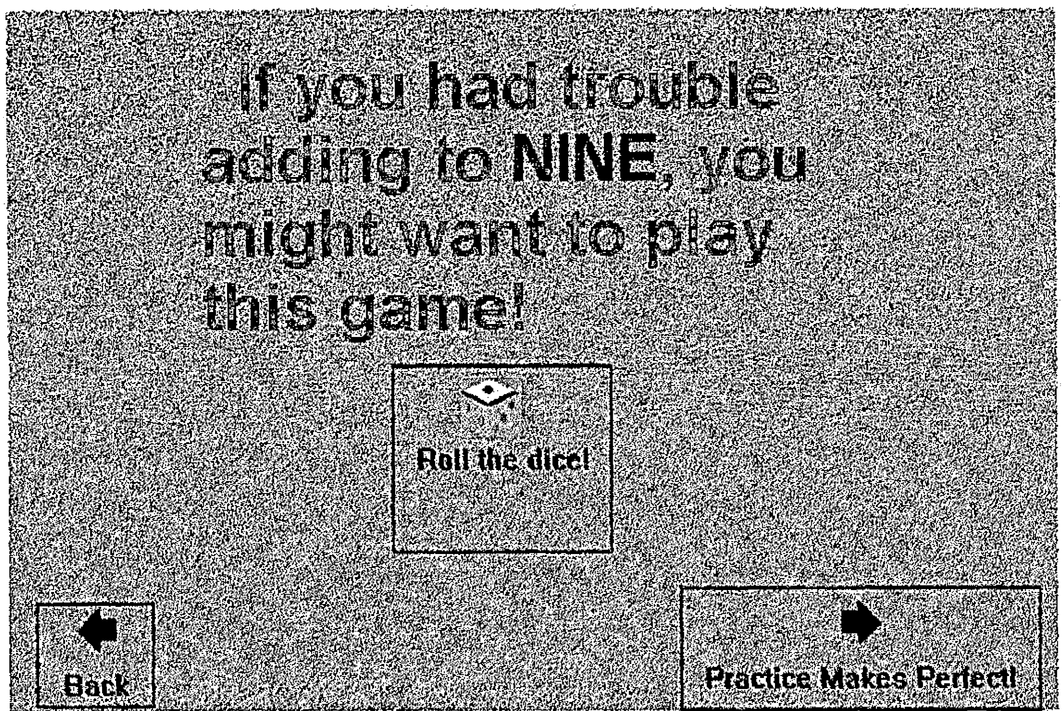

Figure 10. More Games

These spaced repetitions and motivating game-like formats require that the strategies be both retrieved and used. These spaced repetitions help to insure the retention of the strategies.

At another navigational site, the students can elect to take a short learning style quiz. Howard Gardner wrote in 1993 that it is important for students to be in touch with their multiple intelligences. This feature was intended to be an elementary version of "meta-cognitive" planning. The students can decide if they wish to find out more about their learning preferences (Figure 11).

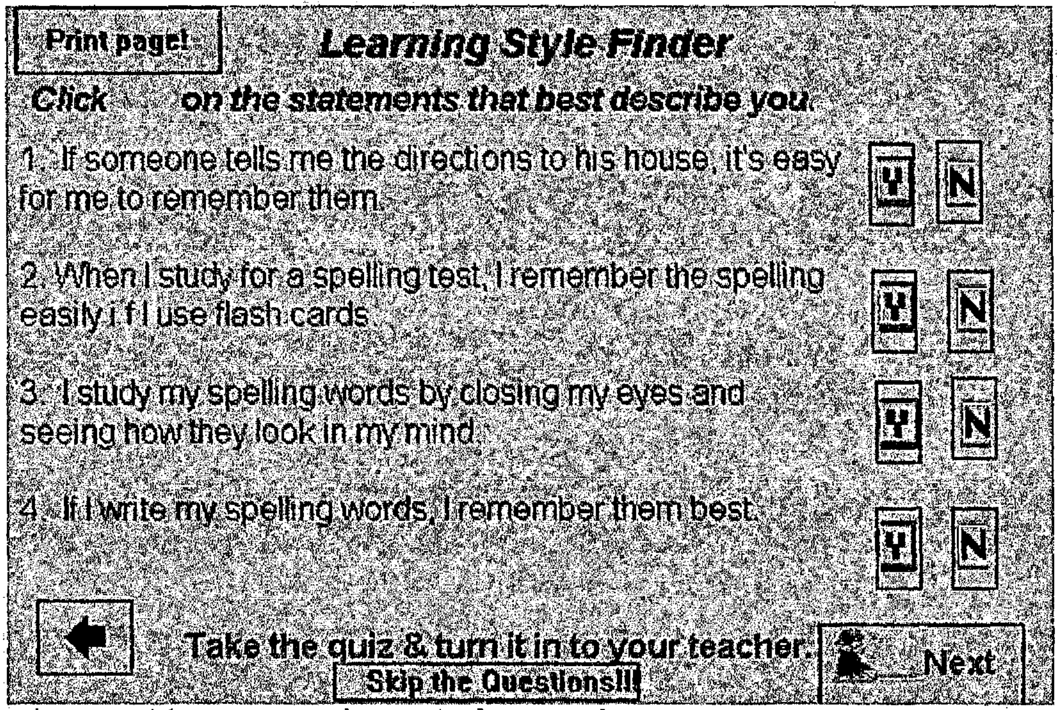

Figure 11. Learning style Card

Functionality and usability are very important design considerations, especially when designing with multimedia authoring systems (Kristof, 1995). For functionality it became important to look at the big picture, or the forest (goal) and important to look at the close-up, trees (how the controls in the project work together). There was an "invisible hand of structure" underlying the basic design of this project (Kristof, 1995). The storyboard feature of the HyperStudio software was relied upon in the design process. Also, a flow chart was designed to help guide the "invisible hand."

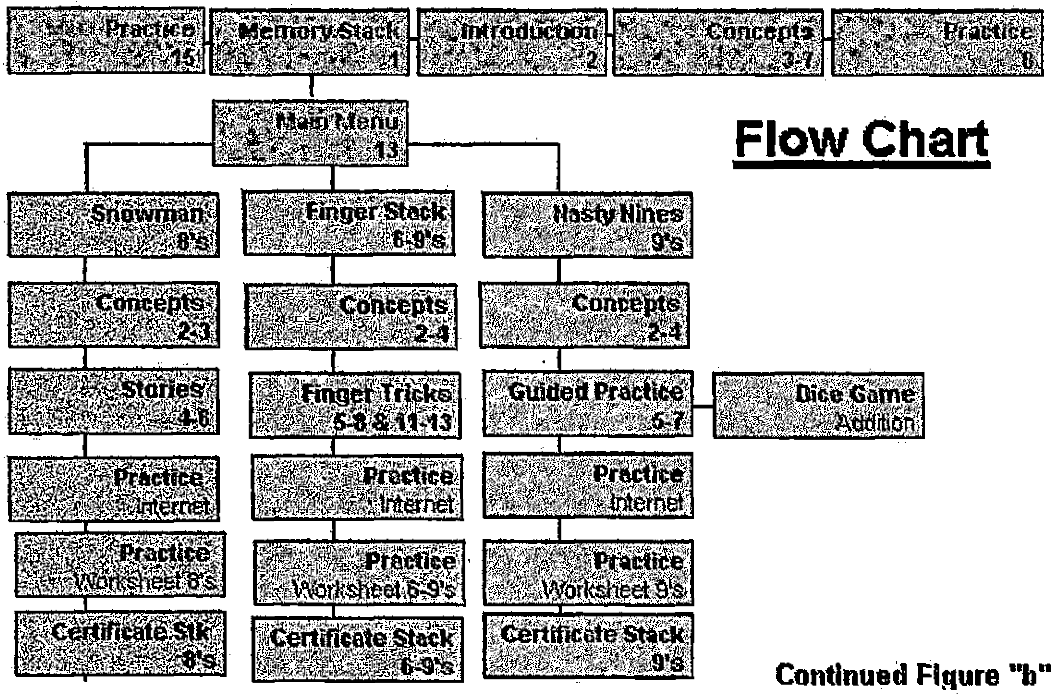

Figure 12a.

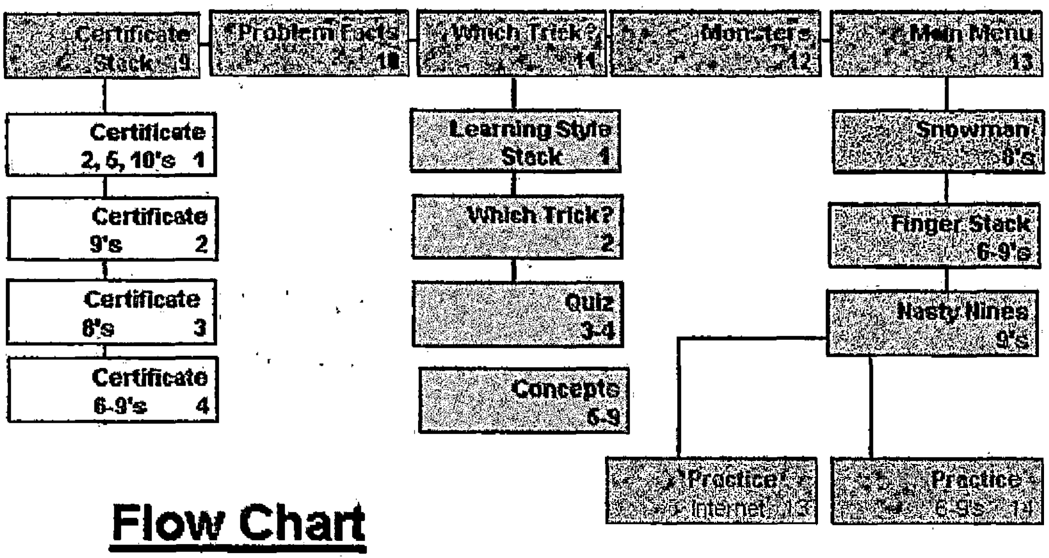

Figure 12b.

In designing for usability, the most important consideration for the project was to aim for simplicity (KISS, or, keep it simple, silly!). It is hoped that in this project all of the controls were designed to minimize effort. Another way of stating this would be that buttons were designed to be easy to use. It was intended that navigation be user friendly. The attempt was made to keep the navigation throughout the project simple. An effort was made to minimize effort, redundancy and travel. It was intended that the main menu screen for all of the strategies would be the "gateway" to the strategies presented (Kristof, 1995).

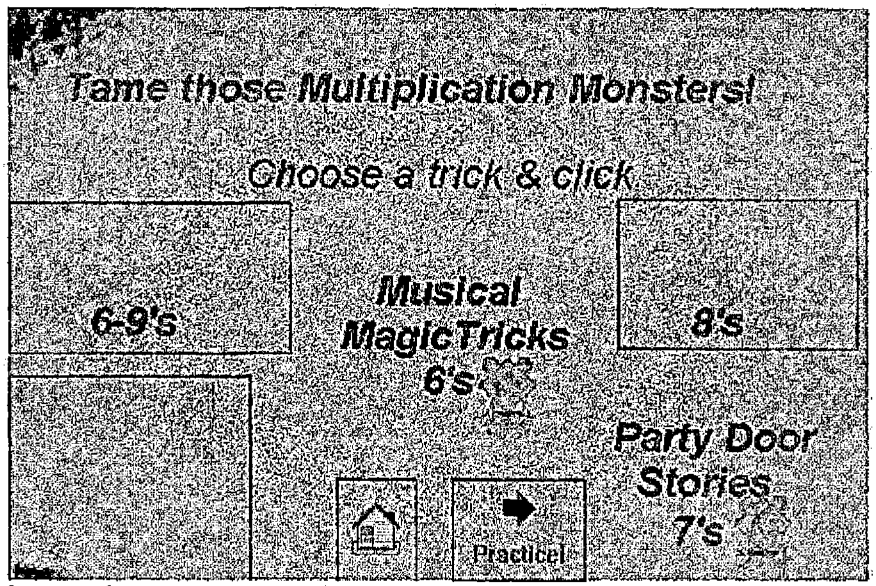

Figure 13. Main Menu Card

The interactivity components of this project were designed to be user friendly as well. The design of buttons was kept simple and consistent throughout. Buttons were clearly labeled for user guidance. It is intended that the student have control of their learning. The student as the user also has choices. For example, if a user of this project has already visited the learning style quiz, been through the basic introduction and learned a particular strategy, he or she has the choice to visit any of the other strategies presented or just do some controlled practice.

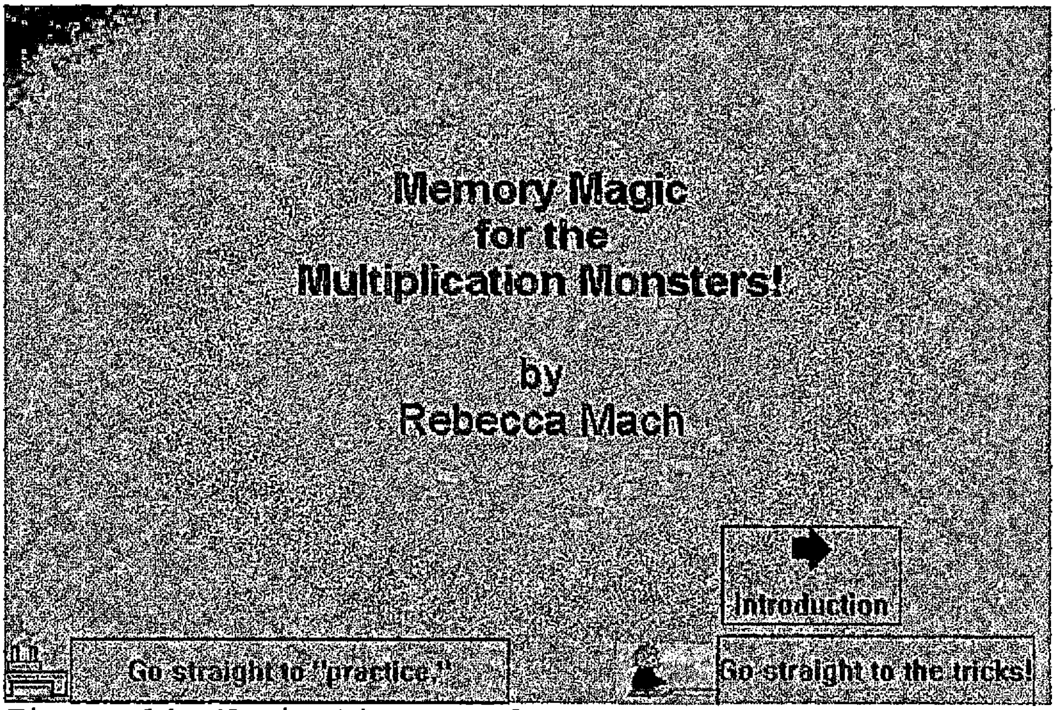

Figure 14. Navigation Sample

An example of the ease of navigation can be given through the presentation of the more difficult products of the 8's. These were presented by way of visual and auditory channels (picture stories). These were displayed to the students on subsequent screens, one picture story per screen. The buttons were designed to allow the student to navigate to review the previous picture story (back) or to view the next picture story (forward). After presentation of all of the picture stories, the student is guided toward practice activities, reinforcing games or allowed to return home.

In my review of the literature, it became clear that an important variable in designing a project for student use was that of motivation ((Scott, Kahlich & Baker 1994). Since students will be asked to learn facts that have been difficult for them in the past, these students will need to be motivated. These students will need to "persevere" on the task. It has been shown that frequency of reward and evidence of success will increase students' perseverance (Carroll 1963). It was with this research in mind that screens were designed to attune the students to the fact that they were doing well. Students were afforded the opportunity to print their own certificates as they progressed. It has been shown that praise and reinforcing students for progress will result in greater commitment to learning and achievement (Pressley, 1996).

Figure 15. Certificate Card

Formative Evaluation

Perhaps one of the most valuable components in the process of the design of this project was the implementation of the "formative evaluation." The purpose of the formative evaluation was to test the computer-based program for effectiveness. Further, the formative evaluation offered ideas for revisions prior to actual use. The evaluations, especially the comment sections, were extremely helpful.

The evaluators were all professional educators involved in California public school setting. Ten professionals were selected to test this project. All of the professionals evaluating this project have had experience with at-risk student populations for which this project was designed.

The professionals chosen were all volunteers. The procedure for the evaluation began with a hands-on interaction with the software. These volunteers spent twenty to forty minutes reviewing the project and the opportunity to interact with the software to determine its instructional effectiveness. Then they were asked to fill out the formative evaluation sheet (see Appendix A and B). The results of the formative evaluation have been tallied and presented in Appendix A and B.

From the formative evaluation forms and comments, it was determined that some revision needed to be made immediately. For example, the formative evaluation revealed that there were no cards in the stack that communicated to the students the exact goal of the program. This card was designed and immediately included in the main (home) stack. Another comment from a school psychologist who reviewed the stack was that the high pitched tone of the "open note" sound wave offered by HyperStudio might prove distracting to a large number of at-risk youngsters. A more pleasing musical tone was chosen for the buttons. One of the professionals who evaluated the project suggested that a choice to go directly to the practice be permitted when the program opened up for the students who had already completed the strategies. This was incorporated as a direct result of the formative evaluation.

Strengths and Limitations

From the formative evaluation, one of the strengths that reviewers strongly agreed upon in the comment section was that the design of the project would be motivating to students of the intended age group. The graphics, audio, and text were rated as very exciting and fun to work with. The reviewers, also, agreed that the structure of the program was a strength of the project. They felt that the format was consistent and easy to follow, yet it was not monotonous. Therefore, the students should not become confused with jargon, or with fancy navigation buttons. The navigational buttons are consistent and easy to follow.

The material presented was relevant and familiar to the user. All students are required to and pushed toward the memorization of their multiplication facts. The relevancy of the material should spark the interest of the students and motivate them to learn their multiplication facts. Another strength of the project is the simplicity of design. The graphics, audio, screens and information are kept at a very simple level. The students are not confused with jargon that they do not understand or with fancy navigation buttons that lead them in circles. According to the literature review (Carroll, 1975) time on task is very important to mastery learning of material. An advantage of this project is that students can spend as much or as little time as it takes to learn this skill. The strategies are fun and easy to visualize and remember.

A major limitation of the project was determined through the review of the formative evaluations. This project does not have multiple levels of instruction. Students are not challenged to take their newly acquired proficiency in the multiplication process to higher levels. Additionally, I think that more should be offered in the line of motivating games so as to maintain the level of involvement. There are several games that I offer to play in "real-time" with my students that really involve them in controlled practice in the facts being studied.

Recommendations

I intend to flesh out this project and complete the two stacks that are currently "under construction." I intend to field test this project with my next year's high school students who may be struggling with the multiplication facts from six through nine.

Future projects should look more into the design of software that will motivate at-risk students toward the mastery of the multiplication facts. All of their subsequent work in the areas of mathematics would benefit from this skill. I believe that this project is a good start. I have seen programs that offer these varying strategies, but not electronically presented. The advantages of presenting them in an interactive, singly packaged multi-media format are great. As technologies improve and with game-software products becoming more user friendly, this project could easily be extended, improved and made even more effective. I already have plans to implement changes that resulted from a close study of the formative evaluations. For example, I want to activate many of the "Read Me" or "Tell me the Story" buttons for the many at-risk youngsters that may not be able to read the text that is presented. Instructional technologists must realize that traditional ways of learning are not always suitable for all students. It was presented in the literature review that students learn differently. It must be understood that students learn differently and deviations from traditional ways of teaching are sometimes necessary to reach at-risk students. Teachers effort to build positive relationships with these at-risk populations are encourage by way of this project. Feedback is directly presented by the teachers for completed controlled practice sheets. The teacher can also make a big deal when a student earns and prints for him or herself a certificate of completion. This will further help these students to have positive school experiences and good relationships with their teachers. In many ways this project this projects fosters mutual understanding, respect and trust between the students and their teachers. Here is just one more example of how technology can support the educational values in our society.

APPENDIX A: SAMPLE OF FORMATIVE EVALUATION SURVEY

Formative Evaluation Survey

****

Please evaluate this HyperStudio Stack for "Instructional Quality."

(SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree and NA = Not Applicable)

****

1. Useful in a school-based, instructional setting. SA A D SD NA
2. Approach is appropriate for intended student population. SA A D SD NA
3. Learning objectives are stated and well defined. SA A D SD NA
4. Allows ample time for progress in one class period (30-40 minutes). SA A D SD NA
5. Learner can alter or control program sequence and pace. SA A D SD NA
6. Saves time when compared to other means of lesson presentation. SA A D SD NA
7. Multiple levels of instruction are available. SA A D SD NA
8. Stack provides opportunity for controlled practice. SA A D SD NA
9. Content is accurate, motivating and free of bias or stereotyping. SA A D SD NA
10. The Stack was easy to navigate. SA A D SD NA

Suggestions for improvement to the stack:

APPENDIX B: RESULTS OF FORMATIVE EVALUATION SURVEY

Formative Evaluation Survey

****

Please evaluate this HyperStudio Stack for "Instructional Quality."
(SA = Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree and NA = Not Applicable)

****

	SA	A	D	SD	NA
1. Useful in a school-based, instructional setting.	10	0	0	0	0
2. Approach is appropriate for intended student population.	7	3	0	0	0
3. Learning objectives are stated and well defined.	4	3	2	0	1
4. Allows ample time for progress in one class period (30-40 minutes).	8	2	0	0	0
5. Learner can alter or control program sequence and pace.	6	3	1	0	0
6. Saves time when compared to other means of lesson presentation.	7	3	0	0	0
7. Multiple levels of instruction are available.	3	3	3	1	0
8. Stack provides opportunity for controlled practice.	7	3	0	0	0
9. Content is accurate, motivating and free of bias or stereotyping.	8	2	0	0	0
10. The Stack was easy to navigate.	5	5	0	0	0

Suggestions for improvement to the stack:

- *Certificate Reward: Consistently reward at mastery of each level*
- *More audio explanations needed for readers with limited skills*
- *Perhaps include more games*
- *Liked the use of multiple intelligences and learning styles*
- *Put a button at the beginning to take the students directly to practice opportunities*
- *Possibly change button sound "open note" to a less high frequency pitch (i.e. harp)*
- *Button sounds for each stack should be the same within each stack*
- *Student population could go up to 12th grade (especially for learning handicapped populations)*

APPENDIX C: COPYRIGHT PERMISSION

To: arthurmach@earthlink.net

At 02:22 AM 6/7/99 -0700, you wrote:
>Dear Shirlie Sharpe,
>My name is Rebecca Mach. I am working on my master's thesis, and would
>use the fish, sharks, hamsters and the sound waves for my master's
>project. I would be very grateful if I may use the graphics and waves
>for my project. Please advise. Thank you.
>Rebecca Mach
>

Rebecca,
You can certainly use my graphics and waves. Let me know how your project goes.

Shirlie L. Sharpe
About.com Guide to Freshwater Aquariums
http://freshaquarium.about.com
email: freshaquarium.guide@about.com

APPENDIX D: COPYRIGHT PERMISSION

Subject: Re: permission to use Work Sheet Factory Lite
Date: Tue, 08 Jun 1999 05:34:37 -0700
From: "WorksheetFactory.com" <rdinch@worksheetfactory.com>
To: arthurmach@earthlink.net

Dear Becky,

Thanks for the information.

Yes, you most certainly can have our permission to use Mathematics Worksheet Factory

The Lite program is "freeware" and so is available for free to anyone who would like

I hope the project goes well!

Bonnie Saligo
WorksheetFactory.com
http://www.worksheetfactory.com
rdinch@worksheetfactory.com

*********** REPLY SEPARATOR ***********

On 1999-06-07, at 9:15 PM, Arthur Mach wrote:

```
>As a remedial teacher I work with Learning Handicapped youngsters. For my Master's
>help my students practice their multiplication facts.  Your wonderful program will
>students the opportunity to be in control of their own learning.  I have made an in
>own specific worksheet.  This will greatly empower them and increase their self est
>classroom only as I am just a beginning traveler in this terrifying information age
>
>Thanks for responding so quickly,
>"Becky" Rebecca Mach
>
>"WorksheetFactory.com" wrote:
>
>> Dear Ms Mach,
>>
>> Thank you for your note.
>>
>> It would help in making our decision if we knew just a little something about you
>>
>> Bonnie Saligo
>> WorksheetFactory.com
>> http://www.worksheetfactory.com
>> rdinch@worksheetfactory.com
>>
>> *********** REPLY SEPARATOR ***********
>>
>> On 1999-06-07, at 1:42 AM, Arthur Mach wrote:
>>
>> >Dear Web master,
>> >In the previous e-mail to you,  I forgot to mention my name.  My name is
>> >Rebecca Mach, a Resource teacher at Corona Norco Unified School
>> >District.  I am currently  working on my master's degree in Etech at
>> >the California State University of San Bernardino.  I am asking your
>> >permission to use your Work Sheet Factory Lite in my master's project.
>> >Please advise.   Thank you.     Rebecca Mach
```

APPENDIX E: COPYRIGHT PERMISSION

Re: kids 3-d dice

Subject: Re: kids 3-d dice
Date: Mon, 07 Jun 1999 08:43:45 -0400
From: mj@latticeworksw.com
Organization: LatticeWork Software
To: arthurmach@earthlink.net

Arthur Mach wrote:
>
> *Dear web master,*
> *My name is Rebecca Mach. I am working on my master degree project on*
> *children education. I am planning on using your game to demonstrate the*
> *addition game. May I have the permission to use the program for my*
> *project ? Please advise. Thank you in advance. Rebecca Mach*

Yes, you may use any of our educational games for your work on your master's degree. Thanks for letting us know.

Mary Jane DiNardo
LatticeWork Software
http://www.latticeworksw.com

REFERENCES

Allington, R.L., (1988). Looking at special instructional programs for at-risk learners. The Reading Instructional Journal, 31, pp. 36-40.

Bagui, S., (1998). Reasons for increased learning using multimedia. Journal of Educational Multimedia and Hypermedia, 7(1)pp, 3-18.

Baron, M.A., Surprising truths: The Implications of Brain Research. Internet http://www.nauticom.net/www/cokids/brain.html

Berger, E.H., (1981). Parents as Partners in Education, C.V. Mosby Company, St. Louis, pp. 1-18.

Bloom, B.S. (ED), (1968). Evaluation Comment, May 1968, vol. 1, No. 2, pp. 5-31.

Bryson, M., & Scardamalia, (1991). Teaching Writing to Students at-risk for Academic Failure. British Columbia, (ERIC Document Reproduction Service No. ED 338 729).

California Department of Education Publication: Sacramento (1994). I Can Learn. pp. 10-17 & 49-60.

Cannings, T.C., & Finkel, L. (1993). The Technology Age Classroom, Wilsonville, Oregon: Franklin Beedle & Associates, Incorporated.

Canter, L., (1991). Parents on Your Side, Lee Canter & Associates, CA, pp. 6-8.

Carroll, J.B., (1963). A model for school learning, Teachers College Record, 64: pp. 723-733.

Colby, R.G., (1995). Experience based writing and the at-risk student. VA, (ERIC Document Service No. ED 384 047).

Croft, D. J., (1979). Parents and Teacher, Wadsworth Publishing Company, CA, pp. 33-36.

Deci, ***

Duckworth, S., & Taylor, R. (1995). Creating and assessing literacy in at-risk students . . . Reading

Improvement, 32 (1) pp. 26-31.

Duttweiler, P.C., (1992). Engaging at-risk students with technology. Media and Methods, 29(2) pp. 6-8.

Foriska, T.J., (1993). What every educator should know about learning. Schools in the Middle, 3(2) pp.39-44.

Fox, B., (1990). Antecedents of literacy, Social Policy Report, IV, pp. 1-19 & 69-75.

Gaddes, W. H. & Edgell, D., (1994). Learning Disabilities: Research and Practice, Springer-Verlag, New York, pp. 296-297/447-448.

Gagne, R., (1992). Principles of Instructional Design, Harcourt Brace Jovanovich Publishers.

Gardner, H., (1983). Frames of Mind, Basic Books, New York, pp.34-44.

Gardner, H., (1993). Multiple Intelligences: The Theory in Practice, Basic Books, New York, p. 21.

Gentile, L.M., & McMillan, M.M., (1990). Literacy through literature, Journal of Reading writing and Learning Disabilities International, 6(4), pp. 383-393.

Golay, K., (1982). Learning Patterns & Temperament Styles, Manas Systems, Fullerton, CA, pp. 27-34.

Heinich, R., (1993). Instructional Media and Technologies for Learning, Merrill, Engelwood Cliffs, New Jersey, pp.***

Hornbeck, D.W. (1990). Technology and students at-risk of school failure. MN. (ERIC Document Reproduction Service No. ED 327 175).

Keirsey, S & Bates, M. (1984. Please Understand Me, Prometheus Nemesis Book company, Del Mar, pp. 27-34.

Kinnaman, D., (1993). What's the research telling us? Technology and Learning, ***

Kozma, R.B. & Croninger, R.G (1992). Technology and the fate of at-risk students, Education and Urban Society, 24 (4), pp. 440-453.

Kristof, R., (1995). Interactivity by Design, Adobe Press, Mountain Vieew, CA, pp.***

Lewis, R. B., ET AL(1987). Special education technology in action: Teachers speak out. San Diego; San Diego University.

Lewis, R. B. (19930 Special education technology: Classroom applications. Pacific Grove, CA: Brooks/Cole Publishing Company. Department of Special Education.

Ornstein, A.C. 7 Levine, D. U., (1994). Foundations of Education. Houghton Mifflin Company, Boston pp. 547-549.

Payne, B. & Payne D. (19910. The ability of teachers to identify academically at-risk elementary students. Journal of Research in Childhood Education, 5(2), pp. 116-126.

Piaget, J. (1970). Piaget's Theory,P.H. Mussen (ED) Charmichael's Manual of Child Psychology, Wiley Press.

Pressley, M. ET AL, (1996). The challenges of instructional scaffolding . . .Learning Disabilities: Research and Practice, 11(3) pp.138-146.

Samples, B.(1994). Instruction Diversity, The Science Teacher, Vol. N (February) pp. 14-17.

Scott, D., Kahlich, P., & Barker, J. (1994). Motivating at-risk students using . . . computers. Journal of Computing in Childhood education, 5 (3-4), pp.311-317.

Sinatra, R., Beaudry, J., Pizzo,J. & Geisert G. (1994). Using a computer . . . Journal of Computing in Childhood Education, 5(1) pp. 93-112.

Sponder,B., & Hilgenfeld, R., (1994).Cognitive Guidelines for Teachers Developing Computer-assisted Instruction. Computer Teacher, 22(8) pp.9-15.

Stemler, L., (1997). Educational characteristics of multimedia: A literature review. Journal of Educational Multimedia and Hypermedia, 6(3-4), pp. 339-359.

Vygotsky, L.S., (1978). Mind in Society: The Development of Higher Psychological Processes. Harvard University Press, Cambridge, MA