1996

Using technology to reinforce the elementary science framework

Earl Joseph Holland

USING TECHNOLOGY TO REINFORCE
THE ELEMENTARY SCIENCE FRAMEWORK

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

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ABSTRACT

The purpose of this project is to develop computer-based instructional material (called a stack) that will integrate technology and science and will also meet the needs of the new state science framework. The study of science and the study of technology have always gone hand in hand. By using this stack, students will not only get the advantages of learning through textbooks and technology; they will also experience the hands-on portion of technology that is encouraged by the new science framework.

This project describes the design and development of a HyperCard® stack that can be used in conjunction with a science lesson about sound. After teaching the concept of pitch discrimination, teachers can create computer-based lessons using authoring software. These lessons can be used to reinforce the understanding of the concept or to address the individual needs of a particular student, class, or grade level.

Although a considerable amount of time goes into the creation of a HyperCard® stack, many teachers can benefit by using the finished product. If teachers could collaborate on the production of stacks, the individual production time could be reduced. The ideas and source material for this stack came from varied materials in a third grade science curriculum.

ACKNOWLEDGEMENTS

I appreciate all the help given to me by Dr. Rowena Santiago in the production of this project. I would also like to thank Dr. Susan Cooper for her help in the many classes leading to this degree. I would especially like to thank my wife Sharron, and my children Mary, Robin, Laurie, and Joey for being patient and understanding during my pursuit of this degree.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

A Need for New Science Curriculum

Many elementary schools today are experiencing rapid changes in the areas of science and technology. The focus in science is shifting to more hands-on experiences, and allowing students to use technology.

Schools are finding that the equipment and resources necessary to teach science involve much more expense than the textbooks which have been adequate in the past. Students learn science concepts from textbooks which are currently available, but reading by itself does not develop the necessary science skills encouraged by the state framework (Woerner, Rivers and Vockell, 1991; Office of Science and Technology Policy, 1992).

Reche Canyon Elementary School in the Colton School District, California is a typical example of a school involved in these changes. Up until this past year, many teachers have relied primarily on textbooks to teach science. This teaching has been supplemented with whole class demonstrations and some hands-on experiments provided by the teachers. Based on the informal interviews conducted by this author with classroom teachers, there is not much uniformity in what is taught among these classes. Due to the effort involved in preparing these experiments, teachers who are not really science-oriented tend to teach a limited amount of science outside of what is found in the textbooks.

One of the positive changes that the school made in 1993 was the purchase of the FOSS (Full Option Science System) kits. These kits have all the lesson plans, handout sheets, and almost all of the required materials and supplies for each group of experiments. The company that manufactures these kits also provides interactive software but the additional cost of this software led to a decision not to purchase this option. The purchase of FOSS kits made organizing the steps of science experiments in the correct sequence and providing the necessary materials and worksheets much easier for the science teacher. However, the kits themselves contain nothing that allows for the integration of science and technology (with the possible exception of videotapes which are for teacher use only and briefly model and explain the experiments).

The lack of hands-on experience with technology needs to be addressed because many students need hands-on experience to learn science concepts. By packaging science activities in such a way that requires and stimulates student interaction, the computer allows teachers who are not scientifically trained to lead students in achieving important insights rather than mere rote memorization of information printed in a book. By simulating experiences that would otherwise be too dangerous, expensive, or time consuming, the computer can help provide an exciting laboratory environment without the frustrations often associated with such labs (Jezercak, 1993; Woerner, Rivers and Vockell, 1991).

Liao (1992) and Gorrell (1992) found that, generally, students who received computer-assisted instruction scored higher on objective tests than did students who received traditional instruction (Fletcher-Flinn, 1995; Geban, Askar, & Ozkan, 1992; Gardner, & Cochran, 1993). Students could also use computers for investigating, reporting, or graphing results (Jezercak, 1993; Hasson, & Bug, 1995).

Science and technology go hand in hand. Physical science, earth science, and life science all rely heavily on computers and technology (Denning, 1993; Jezercak, 1993). Bybee (1993) found that if students are already computer literate, it will make the transition to scientific technology easier in the future.

Technology in the Science Curriculum

To deal with the changes in the science curriculum, one possible solution would be the use of computer software applications to teach science. An informal survey of the software resources available at Reche Canyon Elementary School revealed that there were many software applications that covered the curriculum areas of math, spelling, and language but very little dealing with science.

The lack of software for the sciences and the decision to buy the FOSS materials without the software option resulted in a real need to address science and technology in elementary school. With the advent of authoring systems such as HyperCard®, teachers can use technology to create their own science software (or programs, as it will be referred to in this paper) with the computer and can even have students use this same technology to develop computer-based projects.

Creating computer-based science programs using an authoring system would offer many advantages to students and teachers.

Advantages of Using Computer Based Science Programs

The use of computer-based science instruction provides students with opportunities for interactivity (interactive learning). Gardner & Cochran (1993) define the term interactivity as the user engaging in direct and continual two-way communication with the computer, responding to questions and receiving feedback in reaction to answers provided. In other words, the computer user must be an active participant in the learning process. The potential for a student to be a mere observer of the learning activity is largely removed in computer-assisted instruction. The interactive capability of the microcomputer offers considerable potential to both the learner and teacher (Gardner, & Cochran, 1993).

One appealing advantage of computer-based instruction is that it offers the flexibility to teach higher thought processes such as problem solving as well as relatively simple learning usually associated with stimulus-response learning theory (Media Evaluation Services, 1994). Software can be used for instruction directly related to the ongoing curriculum, for enrichment and supplementary instruction, or for remediation.

Computer-based instruction allows the teacher to more effectively meet the learning needs of individual students. Students do not learn at the same rate (Burns, & Kojimoto, 1992). Unfortunately, typical classroom instruction still does little to take this into account.

Children typically start school at about the same age, follow the same curriculum using the same books and complete the same assignments. The expectation is that these students will attain essentially the same standards. A teacher with 30 students per class is seldom able to devote significant attention to just one student at a time. Computer-based instruction can help meet the learning needs of individual students.

Weller (1995) noted that teachers can benefit by being able to have an individual student review a science concept without taking the teacher's attention away from the rest of the class. Teachers can produce individualized programs that contain only the material they want to teach and exclude irrelevant material (Gardner, & Cochran, 1993). Teacher-made programs can be altered or updated when necessary without the expense of buying a new program. Overall cost will be much less because the cost of disks is minimal compared to the cost of buying new programs or laboratory equipment (Weller, 1995).

Gardner & Cochran (1993) ask the question, "Is it possible to design a single system/program that incorporates all of the information and activities, in such a way that is intuitive and easy for students to use independently?

Because integrated media systems access information in a non-linear fashion, the user is freed from the sequential organization of linear text and able to move through the information along a variety of paths." (Gardner, & Cochran, 1993, p. 251).

For the computer to be an effective medium of instruction, it must do more than imitate the teacher or duplicate textbook information. The computer has the potential to provide information adapted to the needs of the current user of the program, which may vary greatly from the needs of other users.

With the computer, students can pace themselves. They can linger over material that they need more time to absorb or they can speed through material that they quickly understand. In fact, with the computer it is possible to branch a student to remedial material or to jump the student ahead to more advanced material on the basis of the student's response (Gardner, & Cochran, 1993). Also with the computer, students can be allowed choices concerning the format of content within a lesson.

This computer-based M.A. instructional project addresses these needs. It is a HyperCard® stack that can be used to teach a lesson about pitch as a property of sound. This stack includes information about the properties of pitch. It also includes simulations that students can perform using sounds of different pitches. The expense of producing this stack is minimal and the amount of work to produce it is within the capability of the average classroom teacher.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Changes in Science Education

A new Science Framework for California Public Schools was adopted by the California State Board of Education on November 9, 1989. This new framework stresses the need for students to be actively engaged in learning about the natural and technological world in which they live (Honig, 1989). Thematic teaching, coupled with active learning (Fountain & McGuire, 1994), is the best way to provide students with the science education they will need as voters, consumers, and parents in the future (California State Board of Education, 1989).

Active learning refers to instructional activities where students take charge of learning the major ideas in science. There are many ways in which students can be active learners. Science classes that use active learning are typically hands-on laboratory experiences.

In addition to laboratory experiences, the California State Board of Education also lists other forms of active learning, namely active reading, listening, discourse, and the use of new learning technologies, which include the computer (Honig, 1989).

Themes in the New Science Framework

There are six themes developed in the California Science Framework to support its position that thematic teaching, coupled with active learning, is the best way to provide science education (Honig, 1989).

The first theme is energy. Energy can be defined as a bond linking various scientific disciplines. Physical energy is the capacity to perform work or the ability to move things. Chemical energy provides the basis for reactions between compounds. Biological energy provides living systems with the ability to maintain their systems, to grow and to reproduce.

The second theme is evolution. Evolution is generally described as change through time. Evolution is not just the history of natural things. Evolution is also learning about the patterns and processes that shape these things.

The third theme is patterns of change. If students are able to analyze changes it will help them to understand what is happening in a natural system and, to some extent, control changes (particularly in technological applications).

The fourth theme is scale and structure. In studying structure two approaches can be used. A reductionist approach involves the search for the smallest levels of operation of natural phenomena. In a synthetic approach all levels of phenomena in a system are examined to see what roles they play in the overall operation of the system.

The fifth theme is stability. Stability is the study of constancy. Many systems will eventually settle into a balanced steady state or a state of equilibrium. The concept of stability is related to the idea that nature is predictable and that results can be replicated.

The sixth theme is systems and interactions. This is the study of the kinds of interactions that take place in solar systems, ecosystems, and individual organisms.

This project is related to the energy theme. Pitch is a sub-topic of the unit on sound for the third grade.

Problems with Science Learning

Why is learning science so difficult? Science is important but it is often difficult to meet the science goals that are set forth in the state science framework. The Office of Science and Technology (1992) reports that the United States is far behind other countries in science learning as measured on standardized tests. Bybee (1993) reports that students are frustrated by science and need more opportunities to invest in their own learning.

Studies indicate little hands-on science is taught at the elementary school level and that the amount of hands-on assignments and student experiments has actually declined in recent years (The Office of Science and Technology, 1992). Probably the main reason that students are bored with science is because science is not being properly taught and because coverage of textbook material was given so much emphasis (Woerner et al., 1991).

Another reason is that it is very time consuming to use an inquiry mode with hands-on material and actual laboratory experiences. Gardner & Cochran (1993) point out another reason that science is not properly taught is because many elementary school teachers were taught science in elementary school as a reading-only or reading/demonstration activity, in which definitions of words have a connection only to the terms printed on the paper - never to the real world outside of the classroom.

Consequently many teachers feel inadequately prepared to teach hands-on science (Gardner, & Cochran, 1993). The Office of Science and Technology (1992) reports "Few elementary school teachers have adequate preparation in science and mathematics before they begin to teach these subjects. Leading professional associations of mathematics and science educators have established standards for course work preparation for teachers. By their estimates, two-thirds or more of the nation's teachers do not meet these standards." (The Office of Science and Technology, 1992, p. 34). Even though tremendous gains have been made in the past fifteen years in the field of technology and in understanding how learning occurs, there are many teachers who continue to teach science based upon their perception of how they themselves were taught science in school (Woerner et al., 1991). Consequently students feel that "science is boring" and that there are too many vocabulary words and questions (Bybee, 1993).

How Science Should be Taught

Most people learn new science material more effectively on the basis of concrete experience (Bybee, 1993). This idea emphasizes the cognitive development theory formulated by Jean Piaget. Piaget felt that the starting-point and crux of the child's intellectual growth is not sensory perception or anything else passively impressed on him from outside, but his own action. And action in the most literal, physical sense of the term. It is through actively looking and listening, through following and repeating, through exploring by touch and handling and manipulating, that he goes on all the time both enlarging and organizing his world (Bybee, 1993). Many students become capable of handling abstractions during adolescence but abstract reasoning about scientific phenomena will generally not occur unless there is a concrete foundation laid to build upon. There will always be a certain amount of memorization and learning of terms involved in science learning but the operational definitions which the students and teachers themselves formulate as they observe and manipulate science materials will be remembered longer because the meaning attached to those terms was generated by them (students and teachers who developed them).

When considering the capabilities of the microcomputers that we now have and the power and capabilities of the computers yet to arrive in schools, it should require a radical new approach to instruction throughout the entire curriculum. "The modern tools of the teaching trade go well beyond chalkboard and chalk. These days they include desktop computers, videocassette recorders, handy-cams, laser disk players, overhead projectors with liquid crystal displays and large screen monitors. School districts that support the purchase of the equipment and teachers who put high-tech devices to work deepening their students' conceptual understandings will find it easier to reach their ambitious educational goals." (California Department of Education, 1992, p. 46). Montgomery (1994) found that teachers sometimes miss opportunities by adhering to the methods they used in the past.

Computers could be used to enhance science teaching and the learning process much more effectively than they are being used currently. Weller (1995); Geban, Askar & Ozkan (1992) felt that computers can enhance thinking, and change patterns of access to knowledge. Their beliefs are built on the theory of Jean Piaget whose basic idea is that successful learning takes place when children are allowed to construct ideas for themselves and use strategies that they devise themselves (Bybee, 1993).

A natural implication in science instruction is for the teacher to present a problem to the students and to provide a certain amount of guidance necessary to solve the problem but to let the students (using the computer with appropriate hardware and software) find the actual solution to the problem. In this way, the students develop better science skills as well as a whole new conception and set of attitudes toward science as compared to the memorization of science facts when using the traditional methods.

Raymond (1995) and Watson (1993) point out an additional advantage: The computer can also support active learning and the development of science skills by simulating laboratory experiences which are too costly or dangerous. On a very sophisticated simulation there are laboratory experiments and laboratory instruments which are computerized and which enable the student to collect, analyze and present data in graphic forms without ever having to leave the classroom and go to an actual laboratory.

How Computers Support Science Learning

Woerner, et al. (1991) found that a learning cycle approach is the most natural and flexible approach for teaching most science concepts and processes. This approach consists of three phases- exploration, concept introduction, and concept application.

During the exploration phase of the learning cycle, students learn through their actions and reactions in a new situation as they explore new materials and ideas, with guidance from the teacher and the curriculum materials. These new situations should raise questions that students cannot resolve with their accustomed ways of thinking. It should also lead to the identification of patterns of regularity in the scientific phenomena being studied.

The second phase, concept introduction, includes the introduction of a new concept or set of concepts such as cell, metabolism, kinetic energy, tsunami, and so on. This phase usually involves the introduction of useful terms to describe the patterns identified in the exploration phase. The new concept may be introduced by the teacher, the textbook, a video segment, or a computerized tutorial. This step should follow exploration and relate directly to incorporating the pattern identified during the exploration phase into a usable concept. If the entire pattern has not been identified by students, the teacher should review the contents and reveal the missing portions. It is important that both critical and variable attributes of the concept are dealt with.

In the last phase of the learning cycle, concept application, students apply the newly learned concept or thought pattern to additional samples, some of which are non-examples. Students then broaden the range of applicability of the concept and can generalize it to other situations. In addition, application activities aid students whose conceptual reorganization takes place more slowly or students who did not relate the original explanation to their experiences (Woerner et al., 1991).

In the exploration phase of the learning cycle, the computer can effectively provide students with new situations to explore at an appropriate level.

The computer can be very useful in the concept introduction phase. By using a teacher-made tutorial the student can learn new concepts on their own. The teacher can follow up later to verify that the concepts have been learned correctly.

The phase that the computer is perhaps best suited to is the concept application phase. Students can use the computer to apply the concepts they have learned to other situations.

Examples of computer software for teaching science are reviewed below to demonstrate the capability of computers for supporting science teaching.

Types of CAI Software for Science Teaching

CAI (computer assisted instruction) is a title that represents the full range of activities related to on-line instruction, from the simplest drill lesson to the most comprehensive intelligent tutoring system, while at the same time remaining neutral toward instructional strategy.

Drill and Practice

One of the first uses of the computer in education was for drill and practice computer programs that elicited a student response, provided immediate feedback, and then proceeded to another problem. The computer presented students with randomly generated problems of a specific type, and students stayed with that type of problem until they achieved a certain level of proficiency. After achieving proficiency, students moved to problems of a more difficult and/or different nature.

Since the 1960's, drill and practice computer software has remained very popular and has been widely produced for most subject areas. Drill and practice began with the teaching machines of Sidney Pressey and B. F. Skinner. The theory behind drill and practice is that the immediate feedback given to the student acts as a reinforcement to the student and will increase the probability that the same response will occur again in the presence of the same stimuli.

Most educators agree that the computer offers some very useful capabilities for drill and practice; most also agree that the computer can do far more for education than run drill and practice exercises for children. Although some drill and practice software is still being published, emphasis has switched to more complex programs that emphasize higher order thinking skills.

Advantages of Using Computerized Drill and Practice:

1. Immediate Feedback. Probably the most obvious advantage of computer drill and practice is that students can receive immediate feedback to their responses. There is no waiting for the teacher to grade the paper. Students using computer drill and practice do not "practice their mistakes" because they are alerted the first time they make an error. This contrasts with a student completing worksheet type drill and practice assignments where they will frequently make the same mistake 25 times until feedback from the teacher is received.

2. When using a quality drill and practice program, students can progress at their own speed. The program will determine when a student has mastered a concept and then place the student in the next higher level. Students completing paper and pencil drill and practice assignments frequently finish more (or less) items than are necessary for mastery of a concept. In computer-assisted drill and practice, the program determines the optimum number of items for each student.

3. A quality computer drill and practice program can also provide individualized feedback to student responses. The program need not just respond that an answer is right or wrong, it can also give individual feedback about the type of

mistake made by the student. Thus, if a student responds that 62-19 is 47, the program can point out that the student has subtracted the minuend (bottom number) from the subtrahend (top number) and explain why this cannot be done.

4. Efficient Record Keeping. Most newer drill and practice programs contain fairly sophisticated record - keeping functions. With these functions, information is kept on the progress of each student in a class. At any time, the teacher can access these records and determine at which level the student is operating, the amount of time the student has spent on the program, or specific concepts that have been difficult or easy for the student.

5. Motivation. Many computer drill and practice programs appear more motivating for students than typical workbooks or teacher-made dittos. The use of graphics and sound, the motivation of immediate feedback, and the novelty of working on the computer are all factors that may increase time on task for students performing drill and practice activities.

Tutorial

Computer tutorials, as the name implies, are programs that are designed to act as tutors or teacher for students. In a tutorial, concepts are presented and students are given an opportunity to interact with these concepts, much as they would with a teacher.

Like drill and practice programs, computer tutorials vary tremendously in quality. Many early tutorials available on the computer were very simple and unimaginative in design.

Some of these programs simply presented information on the computer screen and occasionally questioned the student about the information.

A good program presents information to the student and then gives the student an opportunity to practice using that information. The practice is guided, and the feedback is immediate. Properly designed tutorial programs can offer some real advantage to both teachers and students. Currently, computer tutorial systems cannot reproduce the flexibility and personal knowledge of an individual teacher interacting with a student. On the other hand, computer tutorials offer advantages over a single teacher attempting to present material to 30 students at once or over a traditional textbook or programmed text approach.

Advantages of Computerized Tutorial Programs:

1. Interaction. A well-designed computer tutorial should offer opportunities for the student to interact with the material being presented. Throughout the tutorial, the student should have the opportunity to actively participate in the learning experience. This participation must involve more than having the learner answer a series of multiple-choice questions or fill-in questions at the end of sections in the tutorial. Students must have a chance to practice new ideas, ask questions, test hypotheses, and check their learning. One of the distinct advantages of using the computer as tutor is that the student can become a more active participant in the learning process.

2. Individualization. A good tutorial program can adjust the pace of presentation to the needs of each student. Using branching (the route a student takes through a lesson, usually based on their responses to questions) and interactive techniques, the tutorial can provide additional instruction for students who need it and also can allow students who are learning quickly to move through material more rapidly.

3. Efficiency. For most teachers, reteaching a lesson is almost out of the question with regard to time constraints. Computer tutorials can provide an excellent resource in these situations. For some students, the tutorial might provide a second approach for material they have been taught once. While for others, the tutorial can make up for the missed classroom presentation. In both cases, the tutorial can save the teacher valuable time.

Simulation

A computer simulation is a simplified version of a situation that a student might encounter in real life. In this situation, the student can solve problems, learn about procedures, come to understand the characteristics of phenomena and how to control them, or learn what actions to take in different situations (Wolfolk, 1995).

Simulations can be powerful tools for learning. Students using simulations are involved in a vicarious experience which can also be very realistic. These experiences fit nicely into a constructivist philosophy of teaching in that students experience life vicariously through the simulation, constructing knowledge about the world from that experience. Simulations may be designed for educational purposes or they may be designed as a virtual reality system.

Simulations are excellent learning tools if they put students into an interactive discovery mode (Teague, & Teague, 1995). They are most effective when the interaction is combined with a realistic amount of feedback. Many CAI simulations that are available are somewhat weak in that they are removed from reality by the limitations of a relatively unsophisticated computing environment. In spite of this weakness, students have little difficulty suspending disbelief and often become quite involved with software that takes them through the steps of a science experiment, or historical sequence of events and prompts them for feedback to monitor understanding (Poole, 1995).

Compact Disk-Read Only Memory

The technology behind compact disk-read only memory (CD-ROM) was a direct outcome of the development of mass-produced lasers. For the CD-ROM to work, a technology had to be perfected by which light is generated in regular waves, so that it can be focused into a very small tight, ultra-small beam. It was also necessary to contain the whole mechanism into a small, compact package that could be connected easily to a microcomputer.

CD-ROM drives are able to read digital information from the disk by interpreting the laser beam as it is reflected off the shiny surface of the disk. As the disk is manufactured, tiny pits are cut into the surface. These pits and the smooth areas between them are read as the zeros and the ones that computers process as digital information.

A CD-ROM disk is very durable. It measures four and three fourths inches across. The lower surface is etched at the factory with the lands (smooth areas) and pits, and then the whole surface is covered with a thick coating of clear plastic. This transparent surface can be penetrated easily by the laser beam but protects the lands and pits from wear and abrasion. CD-ROM disks can be handled without damage by students using reasonable care, unlike magnetic diskettes, which are more easily damaged.

CD-ROM disks can hold a great deal of information. One disk has a storage capacity of 550 to 600 megabytes. This huge storage capacity means that one disk can store 15 hours of audio and 15,000 color images or combinations thereof (Bullough, & Beatty, 1991). The entire 20-volume, nine-million word version of Grolier's Electronic Encyclopedia, with its extensive index, does not completely fill the capacity of one disk.

Drives for the Mac and Apple IIe and IIgs computers, the CD-ROM drive for Tandy/Radio Shack's computer, and IBM PCs are available for between $220 and $800. The price has been steadily declining and, by early 1996 the price for a reliable CD-ROM drive should be under $200. This price range makes it possible for many schools to consider the purchase of this exciting peripheral device.

CD-ROM disk technology has advanced to the point where it is possible to purchase disk drives with the capability to record locally produced programs. This technology makes it feasible for programs originating in your school district to be recorded on a CD-ROM disk and incorporated into the local school curriculum. The only drawback to this technology is that it is a bit more expensive than a nonprogramable CD-ROM drive, but as the technology continues to evolve, the price will continue to drop.

Videodisc

The laser videodisc player looks much like a standard record player except that it only plays laser-encoded videodiscs. Unlike the needle on a record, the laser system does not touch the disc, thereby protecting and preserving the disk surface, which in turn maintains the high quality of the medium.

The technology of the videodisc is much like that of the CD-ROM discussed previously. The player retrieves information from a laser beam that is projected on the lands and pits forming the 54,000 concentric grooves on each side of the disk. The lands and pits are interpreted as the zeros and ones that computers process as digital information. The disc spins at 1,800 revolutions per minute and one revolution can play back one frame/image of video information. Thus the player is capable of playing back approximately 30 frames (images) per second during normal play (Bullough, & Beatty, 1991).

The playback speed can also be altered by a still/stop command, which stops the disc on a single frame allowing the laser to read one revolution again and again, thereby creating a high resolution "freeze" or still frame. Other motion controls include slow motion, a process in which the playback is done frame by frame, and Scan, which moves the disc at a fast rate of speed and allows for identification of the various video images contained on the disc. As most video discs come with a printed frame and chapter index and the player has an Index/Frame Display Function, the user is able to see which frame or chapter of the videodisc is being displayed.

Videodisc programs and players have available the use of two separate and discrete audio tracks. The videodisc player can be controlled to play back both tracks at once or either audio track independently. This feature allows for great flexibility in presenting audio materials.

Videodisc players can be interfaced with most makes of microcomputers and are priced between seven hundred and one thousand dollars. This technology provides an exciting alternative to teachers who desire to couple the microcomputer to a device that presents motion and sound with the interactive capability of the microcomputer. Videodisc players have proven reliable and user-friendly. Teachers generally have little difficulty connecting them to a microcomputer and using the various features.

Data Bases

Data Bases are designed to provide a convenient way to store large quantities of data in an organized manner. The data can be arranged, or stored, according to a number of schemes including alphabetical order and numerical listings.

A data base management system (DBMS) is a program that provides an efficient way to access and manipulate the information in a data base (Norton, & Harvey, 1995). When information is needed, the computer is directed to conduct a search for a specific subset of data, which is defined by one or more search keys, and then to display this and perhaps to print it as paper copy.

Most classroom programs are simplified versions of a full-scale DBMS and are generally referred to as file management systems. While not full-featured, such programs have several characteristics that make them convenient for school use. They are generally menu-driven, providing lists of options from which the user makes a selection, which greatly simplifies the operation. They are also relatively inexpensive, many being available as public domain programs. They provide all the features most teachers ever need, including such things as creating original record templates, searching, sorting, and printing hard copy. To enhance the access and retrieval of information, electronic data bases use a logical method for organizing data. Actually the system is not really unique; it is much the same as a teacher might use if he or she were filing traditional paper-based material (Simonson, & Thompson, 1994).

A common teacher responsibility is to create and maintain records for each member of a class. Typically, this involves filling out sheets with such things as the student's name, birth date, and other personal data. Generally, a standard form is provided into which the unique information for each student is entered. When complete, all the students are collected and organized in some order (generally alphabetical) and are then placed in a binder of some kind. Later, when information on a specific student is needed, the teacher searches through the binder for that student's record, which is then examined to find a specific bit of information. This is essentially the same way that an electronic data base is organized and used. The smallest item, such as a birth date, is termed a field in the electronic data base. The term record is used to define the sheet containing all the information for a single student, and the binder with all the records inside is called a file.

Electronic data bases search a file just as the teacher might, looking for a specific bit of information designated with a keyword (birth date, address) but they perform this infinitely faster than is possible for any human.

Certain publishers offer templates designed for use in various subject matter areas that can be used with existing data base programs (Bullough, Sr. & Beatty, 1991).

HyperCard®

HyperCard® is an authoring tool and an organizer of information. This hypermedia (computer-based instruction that is nonlinear and nonsequential) tool can be used to create stacks of information to share with other teachers or it can be used to read stacks of information produced by teachers. HyperCard® is designed to allow users to create programs in which video, audio, and computer information can be organized.

The programing language that is used in the HyperCard® system is called HyperTalk. HyperTalk will allow users to create their own HyperCard® stacks. A big advantage of the system is that because of the way the it is designed, users can create stacks with little or no knowledge of the HyperTalk language. The structure of this language is modular and users are encouraged to modify scripts (programs) to meet their individual requirements. If users want to use HyperCard® in conjunction with a video disk, they can use programs which have already been written and replace the addresses of the videodisk locations with the ones that they wish to use.

When using a HyperCard® stack, the author can allow users to explore information in the stack in different ways. For example, there is a HyperCard® stack designed for use with a video disk. By using this particular HyperCard® stack with a video disk containing paintings from an art museum, students could view the pictures on the video disk in several different ways. Students could quickly find all the paintings by a particular artist. They might want to locate all the paintings with a particular object in them, or they might want more information on one certain aspect of a painting. Students would have the opportunity to explore the paintings in the same way that they might browse through them in an actual art gallery. Using the HyperCard® stack makes the information on the video disk easily accessible to the user of the stack.

HyperCard® stacks, unlike traditional data base managers, can be designed to give students more freedom to explore and to use both graphics and text information in a stack in almost any way they desire. HyperCard® stacks can be used as instructional tools that will let students explore a subject area using some combination of text, graphics, audio, and video information.

The HyperCard® system is designed so that users with very little programming experience can easily create sophisticated educational stacks. Authors are able to "borrow" parts of existing programs or scripts which saves a lot of time when programming a new application. There are many books and articles written about HyperCard® containing scripts that users are encouraged to use. HyperCard® is especially useful in creating exploratory, learner-centered educational programs as opposed to the drill and practice programs that the structure of many authoring languages encourage (Simonson and Thompson, 1994).

Review of Computer Software for Teaching Science

Basic System Requirements

Unless otherwise noted, one can assume the following minimum system requirements for stand-alone programs:

Macintosh

Late System 6 (e.g., System 6.0.5 or 6.0.7) or later; at least 2Mb of RAM for System 6, 4Mb for System 7; any 256-color display; at least one double-density floppy drive; hard drive with from 1 to 10 Mb free space.

MS-DOS Computer

DOS 3.1 or higher; 286 or higher processor (although performance will be better with a 386); 256-color VGA or better display; at least 640 K or RAM; a popular sound card (such as Sound Blaster); at least on low-density 3.5 inch floppy drive (5.25-inch disk generally available by mail); hard drive with from 1-10 Mb free space.

Windows Computer

Windows 3.1 or higher; DOS 3.1 or higher; 386 or better processor; 256 color VGA or better display; at least 2 Mb of RAM (4 Mb recommended); a popular sound card (such as Sound Blaster); at least one low-density 3.5 inch floppy drive (5.25 inch disk generally available by mail); hard drive with from 1-10 Mb free space.

Science Helper K-8. (CD-ROM, 1993) This program comes from The Learning Team, Armonk, NY; 800/793-8326. System requirements: IBM XT, AT, PS2, compatible, Macintosh 6.0 or above with CD-ROM drive. Cost: $195. ©1993.

Science Helper K-8 CD-ROM is a good example of computer software for teaching science (Harper, 1994). This software is a valuable tool for elementary and middle school science teachers and curriculum writers. This CD-ROM disk offers a menu-driven database of about 1,000 activity-based science and mathematics lessons for grades K-8. All lessons on the disk emphasize the interaction with concrete materials in a laboratory setting. To permit effective retrieval, the lessons are categorized by curriculum project, academic subject, content theme, processes of science, and teacher guide title. In addition, the lessons may be accessed by key words and phrases. For example, a teacher may look for all third-grade lessons in life science that emphasize classification skills. Teachers can obtain printouts of desired lessons with appropriate graphics and modify them as needed for their own units of instruction.

Exploring Earth Science. (1994)

Attica Cybernetics Ltd., P.O. Box 1147, Boston, MA 02205. IBM 386 or 486 with SVGA monitor, two megabytes RAM, four megabytes hard disk space, ISO 9660, CD-ROM drive, eight-bit sound card, MS DOS 5.0 or greater, Microsoft Windows 5.1. CD-ROM disk, user's guide (49pp.), teacher's notes (79pp.) $99. (Grades 5- 10)

This program has a flexible, interactive structure that presents an abundance of information. The context of exploration will encourage children to master the material. On the template for the student project, each student enters his or her name, the report title, the default delay, the play mode, and whether to save the work for later use.

The teacher's notes provide a series of 10 units that correlate with Exploring Earth Science. One of the more interesting and unusual topics is the investigation, "Will my gravestone last? A local field excursion." This study of weathering describes how to prepare for a field visit to a cemetery, lists the necessary supplies, and provides the information students need to complete the activity.

In "Star Atlas," students determine not only the time at which they view the stars, but also the place from which they do so. They can also determine how the stars will be labeled and can print the results for further study or testing. The main information display includes a text cell; a viewing cell that may include a still picture, a sound clip, or a motion picture; and a menu line of hypertext links that provide further information (Riggsby, & Riggsby, 1995).

Exploring Earth Science is user-friendly and easy to navigate. The font is easy to read, the audio is clear and concise, and the vivid visuals keep students' interest high.

Gizmos & Gadgets. (1993)

Hardware: MS-DOS computer* (640K) with DOS 3.3 or greater, 10 MHz 286 or better processor, 256-color VGA or better display, sound card and mouse. Windows computer (640K) with windows 3.1 or higher, DOS 3.3 or greater, 10 MHz 286 or better processor, 256-color VGA or better display, sound card, and mouse. Emphasis: Physical science. Grade Level: 2-6. Publisher: The Learning Company, 6401 Kaiser Drive, Fremont, CA 94555; (800) 852-2255. Package includes: Two 3.5-in. high-density floppy disks, or two 5.25-in. floppy disks; reference card and user's guide. Price: $59.95.

Gizmos and Gadgets encourages interactivity and experimentation by featuring on-screen simulations, puzzles, and laboratories where students have access to tools and components that let them put together and try out all kinds of machines (Eiser, 1994)

The object of the program is to depose the mischievous Morty Maxwell, Head Scientist of the Shady Glen Technology Center. In order to do this, kids must design the fastest vehicles they can to beat Morty in a series of races. Each of the 15 races requires them to complete four distinct but interdependent tasks: analyze blueprints and vehicle components; solve science puzzles; explore a labyrinth; and participate in a race.

Students begin at the Technology Center, where they choose one of three warehouses (Aircraft, Alternative Energy, or Automotive) to summon a blueprint for a vehicle. Gas blimps, downhill racers, solar-powered autos, and other imaginative entries are available. Each blueprint identifies several critical components-from wheels and hull shape, to gear boxes and engines. Notes attached to each part further describe what attributes will give the piece the most efficient shape, gear ratio, or engine size. This information becomes important in the next step, when students enter the warehouse to gather components to build their vehicle. As each piece is located, the decision to keep it or recycle it must be made based on its relative value to the finished vehicle. (Since Morty gets better at building his vehicle at each level, picking the right set of components becomes even more important as user expertise improves.) Students can learn a lot about gear ratios, hull shape, and wheel diameter just by paying attention to which combination of choices gives a particular vehicle the best possible speed.

Gathering vehicle components is difficult, as each one sits behind a locked door in the six-floor labyrinth of the warehouse. To open each door, students must solve physical science puzzles such as moving mag-electrical circuits; building simple machines; arranging gears in various configurations; and even cross-matching types of electrical, chemical, and nuclear energy (Wulfson, 1995).

The science content of Gizmos & Gadgets! is well thought out, age appropriate, and graduated in difficulty. Although some of the puzzles are standard fare, those using gears and magnets are innovative and creative and will encourage students to use problem-solving skills (Media evaluation services, 1994). (Elements such as gravity, elevation, oil, and sand can be manipulated to vary the challenge.) Students will learn science applications that can lead to a better understanding of the natural world (Allen, 1994).

Christa's Science Adventure. (1994) Sunburst Communications, Inc., 101 Castleton St., Pleasantville, NY 10570. MS-DOS 5.5 or higher with MS-DOS, Windows compatible with 6.9 megabytes free on the hard drive, 582 kilobytes RAM. Two disks and backups, teacher's guide (61pp.) user's manual (38pp.). $79. (Grades 6-10)

In Christa's Science Adventure, students have to deliver 10 chapters of a science manuscript to the publisher. To find each chapter, students must decipher clues through research, problem solving, and deductive logic. The chapters cover a wide variety of science areas, including biography, mineral science, meteorology, mechanical advantage, mathematics, sound, and nutrition. Students are introduced, in a realistic and motivational way, to science concepts that may be outside their regular curriculum (Demmert, 1995).

To use this program, students must be able to save and retrieve files, communicate with their group and the computer, research science concepts, and think deductively. Also, they must be persistent.

The clear and detailed manual suggests many ways to use the software in laboratories and computer rooms. Demmert (1995) feels that having small groups work for 15-30 minutes at a time over a month or six weeks would be the best way to use this software. It may be necessary to allocate additional time for research, map drawing, and group communication. Christa's Science Adventure is an interactive simulation. This program is a motivational tutorial for general science.

<u>Sammy's Science House</u>. (1994)

Edmark, P.O. Box 3218, Redmond, WA 98073-3218. Macintosh Plus or later, hard disk, System 6.07 or later, two megabytes RAM (four megabytes for system 7.0); IBM or compatible, 3.5" high density drive, hard disk, DOS 3.1 or higher, 640K RAM, VGA or EGA monitor, mouse, 16MHz 803386 or better, sound card. Six disks, user's manual (83pp.). $59.95 (program), $129.95 (laboratory pack). (PreK-K)

Sammy's Science House is an interactive program that introduces young children to basic scientific concepts. The program consists of five activities that develop observing, classifying, comparing, sequencing, and problem-solving skills (Eiser, 1995).

The "Sorting" activity has children classify objects by certain features. In the "workshop" activity, children construct an object by following a diagram and choosing the correct parts from a pegboard display. For both of these activities, children can choose from three levels of difficulty. With the "Weather Machine", children can create their own weather conditions and then view a weather report. The "Make a Movie" activity has children put events in the correct sequence to make a movie. In "Acorn Pond", children observe animals living around a pond and learn how these animals adapt to the changing seasons. A field notebook prints additional facts and a sketch of each animal.

The program provides two interactive modes for most activities. When children enter an activity, they are in the Explore-and-Discover mode and can experiment freely by clicking on objects and icons. At any time, children can click on the framed picture to choose the Question-and-Answer mode. In this mode, a character provides feedback when necessary.

The documentation is clear and easy to follow (Loveland, 1995). Curriculum extensions provide the teacher with whole-class activities that strengthen and reinforce skills. There is also a handout that children can take home.

Sammy's Science House will complement any early childhood curriculum (Media evaluation services, 1995). However, even though the program is designed for the prereader and includes voice and picture icons, young children will need adult assistance when using this program (Lane, 1995).

Understanding Earth. (1994)

Videodiscovery, Inc. Seattle, WA; 800/548-3472. Cost: $569.

This videodisc is an exceptional tool for the earth science classes. It contains 3,000 still images, 90 motion sequences and four mini-documentaries. Video segments and computer animations help explain and promote the understanding of complex concepts. Teachers and students will appreciate the aerial films of land forms and the three dimensional photos of minerals. The visual material quality is outstanding (Tobojka, 1995).

This package consists of one double-sided videodisc, a teacher's manual, six student manuals, a videodisc directory and a barcoded map. The lessons will cover all aspects of earth science including minerals, rocks and the formation of mountains, glaciers and deserts. The teacher's manual provides twelve lesson plans. Lessons are well organized into directions for the teacher, assessment goals, ways to extend the lesson and a bibliography.

The student manual allows the students to follow the teacher through lessons. It also provides guidance for independent work. The great visual and graphical images presented in this videodisc make for an exciting tool to use in high school science classes.

Odell Down Under. (1993)

MECC, 6160 Summit Dr. North, Minneapolis, MN 55430. Macintosh LC (68020 or higher), System 6.0.7 or higher , two megabytes RAM, color display, hard drive, 32-bit Quick

Draw, printer optional. IBM Windows version also available. Three high-density disks, user's manual (23pp.), and teacher's manual (72pp.). $59.95. (Grades 3-12)

Odell Down Under challenges students to survive on a reef by identifying predators, eating enough food, avoiding poisonous plants and animals, and saving energy.

Students begin by choosing from "Practice", "Challenge", "Tournament", and "Create-a-Fish" levels. "Practice" lets students take on the role of one of over 50 fish and explore the reef. In the "Challenge" level, each student is assigned four fish to role-play. As students improve, they face new challenges (Fleisher, 1994). "Tournament" has students play all of the fish in turn as they proceed through the levels. In "Create-a-Fish," students design a fish, modifying such factors as speed, endurance, agility, and whether the fish is diurnal or nocturnal.

The program contains many helpful functions. An information button and box provides players with information on their fish, an icon grid at the bottom shows the fishes' location on the sea floor, and an energy and health bar gives feedback on the fishes' health and energy. Players also can consult a field guide and print out information. Many of the student handouts encourage the students to use the program in a more meaningful way (Little, 1994).

The program provides a master list on which you can keep students' scores. By referring to the manual and entering the password, you can erase scores, change measurements, and set preferences. For instance, you can turn the sound and music on or off. There are many other helpful management options, but most of these are not needed to play the game (Beckerbauer, 1994).

Science 2000. (1994)

System Requirements: Macintosh: Color Macintosh, System 6.0.5 (System 7 recommended); 4MB RAM, 20MB free hard disk space, DOS 3.3, VGA monitor. Videodisc players: Pioneer LD-V2200 or higher, or compatibles. Price: $4,500, available through school site license.
Company: D.C. Health and Co., Lexington, Mass.; (800) 235-3565.

Science 2000 captured headlines a few years ago when the videodisc series produced by Decision Development Corp. was adopted by California (and other states) as a full seventh-grade science curriculum. Since then, D.C. Health has taken over marketing the product, adding a new eighth-grade version.

Science 2000 names its three primary goals as enabling students to enjoy science, to think like real scientists, and to recognize and understand the major themes of science. It identifies these themes as energy, evolution, patterns of change, scale and structure, stability, and systems and interactions, all adapted from the California State Science Framework.

The new eighth-grade curriculum is composed of four major units: The Lost Children: Genetics and Inheritance; The Sun and Global Climate Change; Ears to the Sky: Energy Transformations; and Natural Disasters. The program uses multimedia to help the units' concepts come to life. For example, in the natural disasters section, students see videos of a hurricane's force and volcanoes' eruptions, each accompanied by text and graphics that explain what is appearing on screen and why the phenomena occur.

The videodisc's Level III capabilities (which enable users to control the program with accompanying computer software) let students decide when they are ready to move onto the next unit, or whether to return exactly to the spot where review is needed without having to go through the whole unit.

The publishers have created a comprehensive collection of support materials with this program (Hilts, 1995). There are guides with lots of follow-up classroom activities a teacher can choose from including group activities, discussion, journal writing, and additional experiments. A "Teacher Tips" section presents many teaching strategies and enrichment exercises. The blackline masters are clear and graphically well done, with very good entry questions such as, "Are volcanoes all the same?" The section also provides a means of authentic assessment for concepts and processes presented throughout this program.

At any of these levels, it is appropriate to use a diagnostic prescriptive method with immediate feedback and positive reinforcement. The computer can be used as a tool to facilitate and enhance science learning. It should not become one more subject area for science students to study. The computer should provide a method of integrating science and other thinking skills to provide a more meaningful experience for the student. Not only can the computer motivate learners it can also focus their attention on the immediate task at hand.

All the above examples of computer science software support science skills and science teaching. However of the eight science software programs covered, only three of these programs addressed the unit on sound and pitch in particular. Also important is the fact that these programs range in price from $59.95 to $4,500. This emphasizes the need for science teachers to be able to create their own programs to meet specific objectives.

Science Strategies and Computers

Mastery Learning

One strategy used in teaching science is the principle of mastery learning. Usually when teaching science, the amount of time is held constant while student achievement varies and students are graded accordingly. The idea of mastery learning was developed by Henry C. Morrison in the 1930s. Modern versions have been created by Benjamin Bloom and James H. Block (Saettler, 1990). In mastery learning, equal achievement is the goal for everyone and the time required for learning is allowed to vary. What some students accomplish in twelve weeks might take another student twenty-four weeks. The principle of mastery learning gives rise to two main problems: (1) It is more difficult to group and schedule students. It is easier to schedule everyone to work at a constant pace so that they finish their work at the same time than it is to allow time variations within a group. (2) While the slower learners will require extra time to learn the material, the faster learners will have to wait for them to catch up (Grey, 1992).

According to Woerner et al. (1991), there are three ways that computers can be helpful when using mastery learning.

1. Many students need additional time and individualized practice with feedback to meet objectives. Computer programs can often provide opportunities to study at times and at a pace suited to the individuals needs.

2. Additional programs can be made available for students who master objectives quickly. These additional programs can either provide more intense study of the same objectives, move on to higher objectives, or integrate the objectives covered in the unit with other objectives (Fountain, 1994).

3. Gradebook, record keeping, and other management programs can help teachers keep track of student performance and coordinate instruction.

<u>Direct Instruction</u>

Another strategy used in teaching science is direct instruction. In direct instruction the teacher describes objectives and demonstrates exact steps using sequenced instructional materials. Further characteristics include:

1. Goals that are clear to students.

2. Sufficient and time allocated for instruction.

3. Introduction of terms and concepts.
4. Monitoring of student performance.
5. Questions at an appropriate cognitive level, enabling students to give many correct responses.
6. Immediate and academically oriented feedback.

Direct instruction is most effective in teaching basic skills that are fundamental to more complex activities. This strategy is more valuable for very structured units where a lot of creativity is not required from the students. Direct instruction has a place in each phase of the learning cycle. It is important that the teacher not see direct instruction as strictly memorization of facts. It should be a guidance process. While students do have to learn a certain amount of information directly, it should be a part of the learning process so that they can interact with the materials and work out concepts for themselves.

Direct instruction is a strategy that the computer performs especially well. The computer programs used should state an objective, provide a tutorial, and provide numerous opportunities for practice with appropriate feedback. Even though a computer program might not incorporate all the features of direct instruction, almost any good computer program can be a component of effective direct instruction. It is helpful that the teacher remind students of the objective of a unit of instruction, supply the computer program, specifically point out the relationship between the objective and the computer program, and monitor the use of the program by the students.

This computer-based master's project supports active learning in that students will develop acquisition skills such as listening, observing, and investigating as they complete the sections of this project. They will also develop creative skills as they use the simulation section. The science material in this project supports the theme of energy within the new science framework. The project supports science learning and strategies because it provides the students with necessary guidance. But it still requires them to think in order to successfully complete the sections of the project. It allows for changes since teachers can add new songs to the program as grade level requirements change.

CHAPTER THREE

STATEMENT OF GOALS AND OBJECTIVES

The goal of this master's project was to develop a software program that would make use of available technological resources to supplement the textbooks that are currently being used in science instruction. The California State Science Framework encourages the use of technology and technological resources, yet many teachers make limited use of the resources that presently exist in their classrooms.

It is expected that this project will produce an example of the type of software that teachers can create, use, share and modify to fit their individual requirements. This project deals with the content area of sound and specifically about pitch as a property of sound. Through the methodology applied in this project, it is also expected that teachers will see the advantage of creating HyperCard® stacks, create them for other areas of science instruction, and will work collaboratively to create a custom product that can serve the needs of the science classroom.

The objectives of the computer-based instructional material on pitch and sound that were developed for this project are the following:

1. When the student is given a particular musical instrument on the monitor, the student will be able to determine which instrument has a high, medium, or low pitch based on the instrument's size and shape.

2. When the student is given the first bar of a familiar tune, the student should be able to discern if the pitch of one missing note in the tune is higher or lower than the note before it.

3. When the student is given a guitar on the monitor with notes on the guitar neck representing the frets on a guitar, the student should be able to reproduce a tune of the appropriate difficulty for their grade level when given the notes to the tune.

The stack supports the following science objectives as given in the textbook for sound and pitch.

1. The student should be able to name two ways that sound can differ.

2. They should be able to define the term volume as the loudness or softness of a sound and the term pitch as the highness or lowness of a sound.

3. The student should be able to describe what determines the volume and pitch of a sound.

The second goal of this master's project is to develop a unit plan that will demonstrate how the software program on Pitch can be integrated as part of the instructional design for teaching the unit on sound.

CHAPTER 4

DESIGN AND DEVELOPMENT OF THE CAI PROJECT

Curriculum Framework

The goal of the state-required Science framework is for students to be actively engaged in learning about the natural and technological world in which they live. Because of the accessibility of computers in most classrooms, this project can help classroom teachers meet both of these goals by allowing students to learn about sound using both the required text and the computer.

Users' Grade and Entry Level

This project is intended for use by third grade students. Every effort has been made to keep at a third grade level, the language used in the instructions and the level of computer literacy required to perform the operations of this program. By the third grade, students have already learned basic keyboarding skills and have had experience using several types of games and simulations. They have investigated how their ears are used to learn about sound and they are able to classify sounds as being loud or soft. They are also able to locate the source of various sounds and they can identify various sounds.

Software Content

This project takes the concept of pitch as a property of sound and presents supporting activities in the format of a computer program in addition to a lesson from a textbook. The third grade science textbook presents the concept of volume by explaining that when a drum is hit harder it will make a louder sound, and if it is hit softer the sound will be soft. The book illustrates the concept of pitch by comparing different types of musical instruments. It also compares the low-pitched sound of a tuba with the high-pitched sound of a flute.

This stack will provide students with the opportunity to discriminate between sounds of different pitches from musical instruments by actually hearing the sounds produced. Consequently, they will also improve in their ability to predict the relative pitch of a note in a song that they are familiar with.

The textbook contains an activity for the student to learn about pitch by taking a shoe box, cutting a rectangular hole in the lid, and stretching rubber bands around it. By plucking the rubber bands the student can differentiate between higher and lower pitches. The HyperCard® stack "Name That Pitch" provides a similar simulation in which the student can read the notes of a song and play the song on a guitar by clicking on the correct section of the neck of the guitar. Even though these activities differ, they are complementary and support each other in terms of the principles they teach. The activities found in "Name That Pitch" reinforce these objectives. Through technology, the author was able to incorporate interactive activities that could not be included in textbook presentations.

Software Structure

An overview of the general structure of "Name that Pitch" is given in Figure 1. (the software structure of "Name that Pitch".)

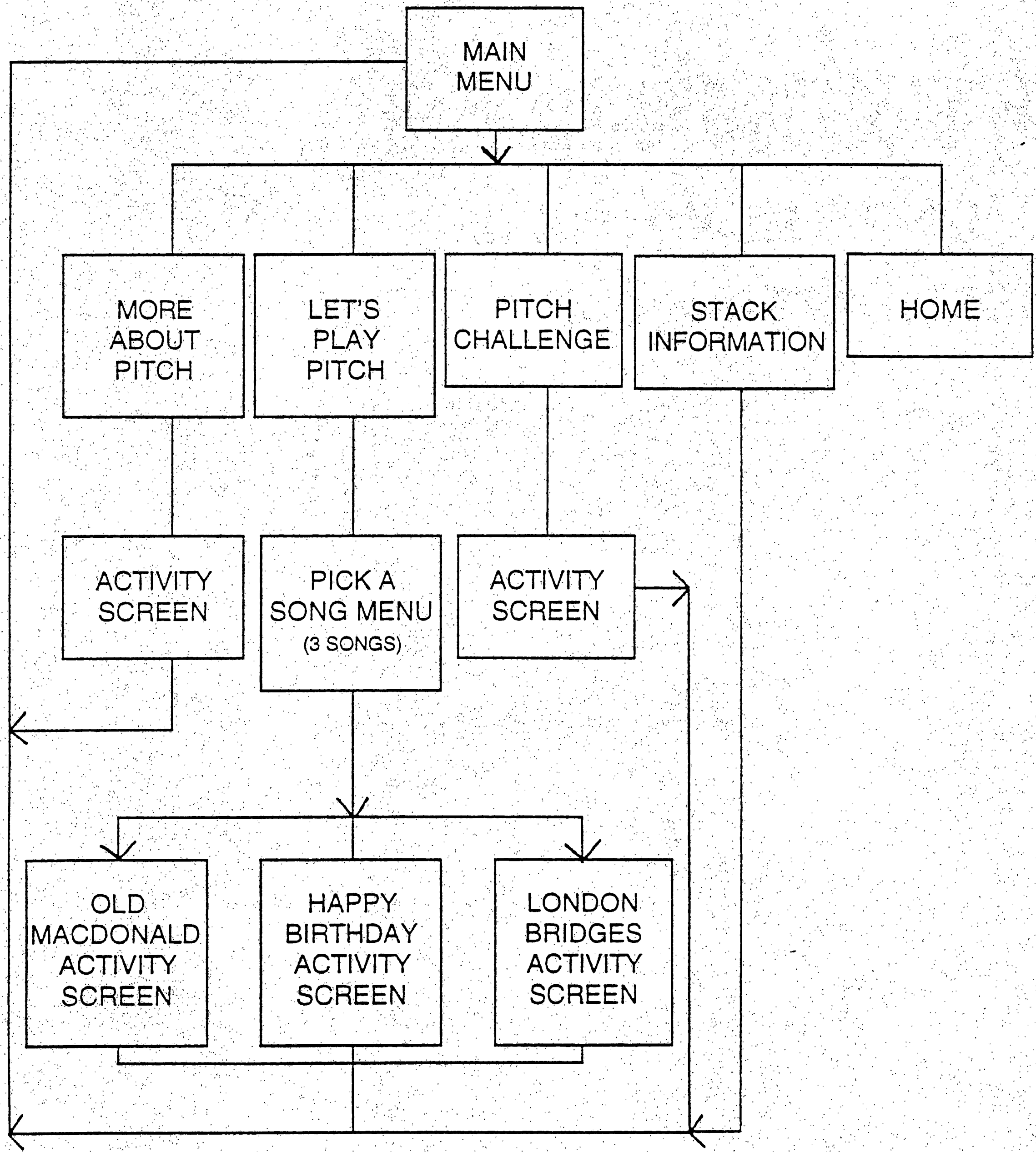

Figure 1. The software structure of "Name that Pitch".

Stack Design

HyperCard® was chosen to create this stack because it was the leading system at the time this stack was designed. HyperCard® is powerful for using music, and it was the only system available at Reche Canyon School. The wording for the directions was selected and revised based on readability and appropriateness for the intended grade level. The buttons were placed on the cards using the following guidelines: Buttons common to every card are in the same place and buttons associated with an illustration are near the illustration. Travel buttons remain visible and care was taken to make sure that pop-up fields don't hide the travel buttons. Attention was given to using appropriate icons for the buttons used in this stack (HyperCard® stack design guidelines, 1989).

Screen Design

As the "Main Menu" Card opens (See Figure 2), the dinosaur plays "The Yellow Rose of Texas" and notes appear as the song is playing. The dinosaur was selected because third grade children are interested in dinosaurs and it gets their attention. The song "The Yellow Rose of Texas" was chosen for its even tempo that appeals to children and its lilting quality. All other music used in this stack was selected for grade level appropriateness and familiarity to most students so as not to interfere with the concept of pitch.

The main menu provides the user with 5 buttons, representing 3 types of options:

1. To get help on how to use the stack (1 button named "Stack Information").
2. To proceed to one of the 3 main sections or activities (3 buttons named "More About Pitch", "Let's Play Pitch" and "Pitch Challenge").
3. To quit by returning to the home stack(1 button with the home icon).

The "Stack Information" button gives the learner a brief overview of the stack and provides an explanation on how to operate and navigate through the stack. This overview field can be hidden by clicking on the button or on the field itself. The three buttons on the bottom of the card "More About Pitch", "Let's Play Pitch", and "Pitch Challenge" take the user to the three main sections of this stack. The home icon-button takes the user back to the home card.

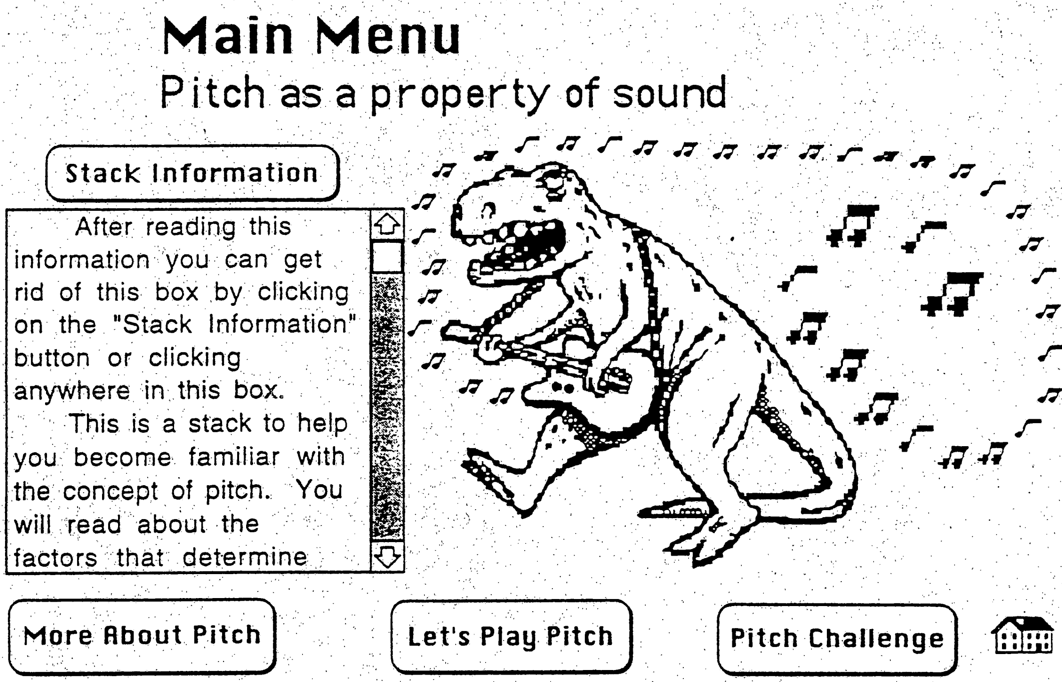

Figure 2. Main Menu of "Name that Pitch".

“More About Pitch” (Figure 3) is the first of three sections of reinforcement activities. This card gives students information about pitch as it pertains to musical instruments. The purpose of “More About Pitch” is to reinforce their understanding of the concept of pitch.

Five buttons are provided on this card:

1. The “Learn About Pitch” button gives the scientific explanation about pitch as it relates to the different instruments.
2. The “Instructions” button opens a field that explains how to use this card.
3. The “Check Answers” button allows the students to verify their answers after they have made their selection.
4. The “Reset” button allows the student to reset the card and try again if their answers are incorrect. The answers will be reset automatically when the card is closed.
5. The “Main Menu” button allows the user to return to the main menu.

A prerequisite to this activity is learning to discriminate between high-pitch and low-pitch.

The learning activity in this section requires the student to match the high, low, and medium pitches to the three instruments shown on the card. They must determine which of the instruments has the high, low, or medium pitch based on the size and shape of the instrument and the length and tension of the instrument’s strings.

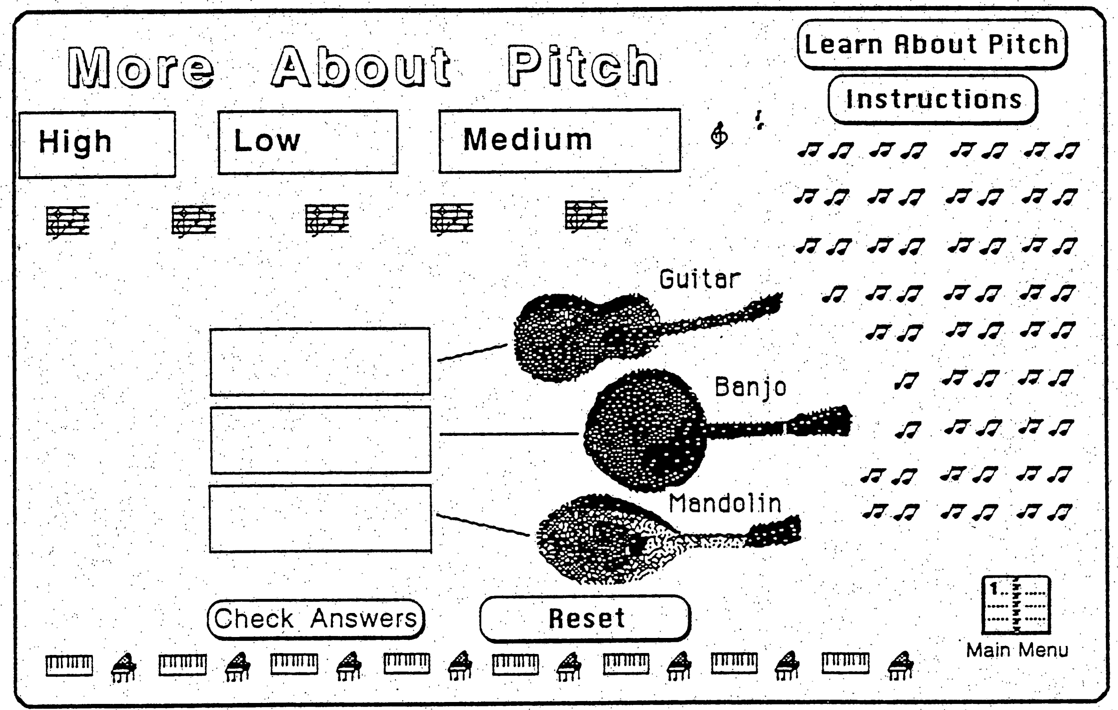

Figure 3. More About Pitch.

When the "Let's Play Pitch" activity is selected from the main menu, the user is directed to the "Pick a Song" screen (see Figure 4). The user can pick a song by choosing from one of the three buttons "Old Mac Donald", "Happy Birthday, and "London Bridges" that are provided at the top of this card. The "Pick a Song" text blinks to remind the student that they must select a song from this card. The main menu icon in the lower right hand corner of this card allows the user to return to the beginning of the program.

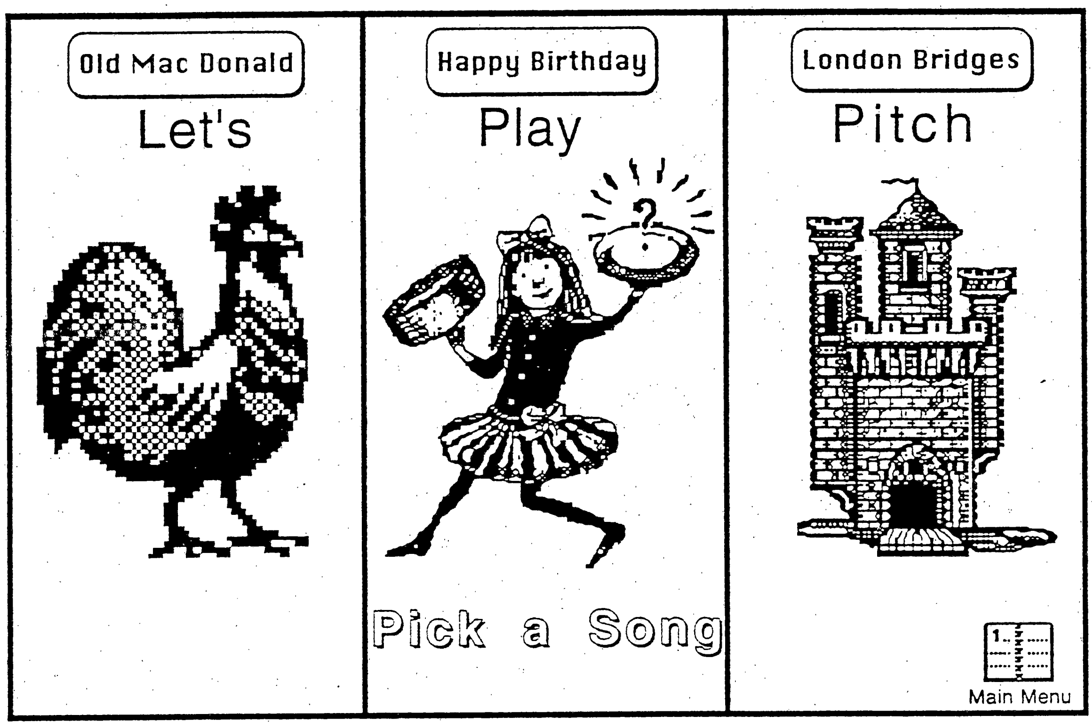

Figure 4. Let's Play Pitch.

The first song card (Figure 5) appears when the student clicks on the "Old Mac Donald" button of the "Pick a Song" card. When this card opens it plays the notes to "Old Mac Donald". An explanation about how to play the game is also automatically typed on the card above the "Start Game" button. The user may begin the game by clicking on the "Start Game" button. The song will play with one note missing. The student may want to hear the complete song to determine what note is missing. The "Play Song" button is provided for this purpose.

The student must decide if the pitch of the missing note is higher, the same, or lower than the pitch of the preceding note and click on the appropriate button. If they identify the pitch correctly, a field will open and give them some positive feedback. If they are incorrect, a field will give them the correct answer and encourage them to try another song. There is a "Next Song" button for the user to go to another song without returning to the main menu.

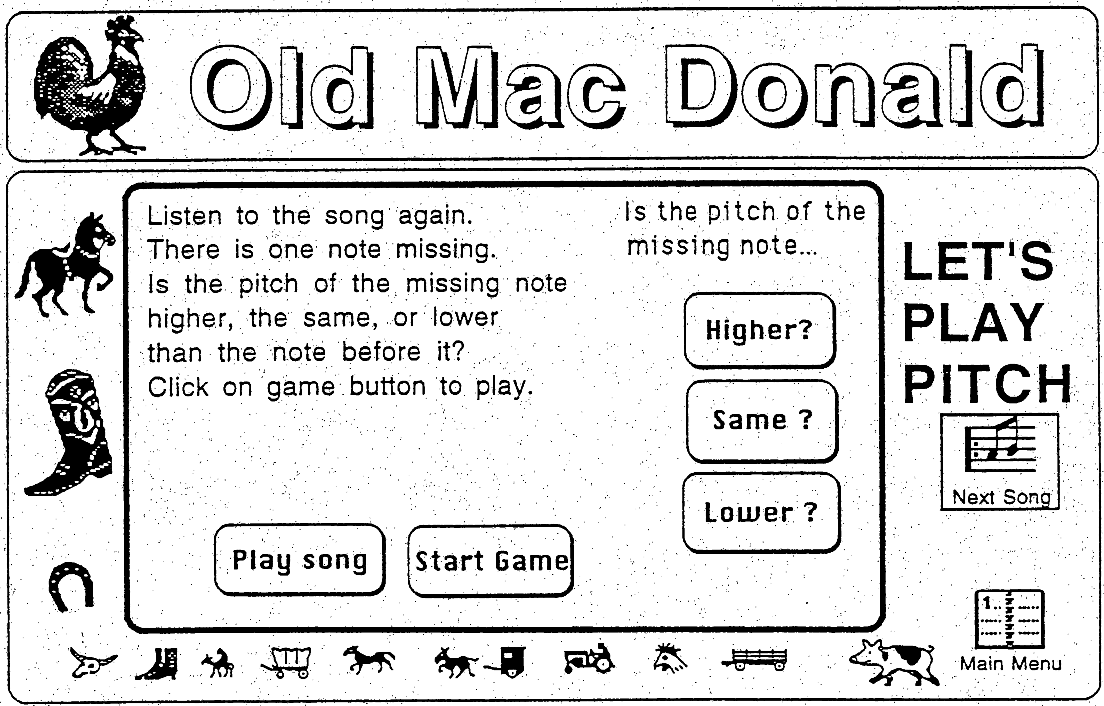

Figure 5. Song card (Old Mac Donald). The Second Learning Activity.

The other two songs ("Happy Birthday" and "London Bridges") for "Let's Play Pitch" are shown in Figure 6 and Figure 7. They have the same basic design and operating procedures as the card for "Old Mac Donald".

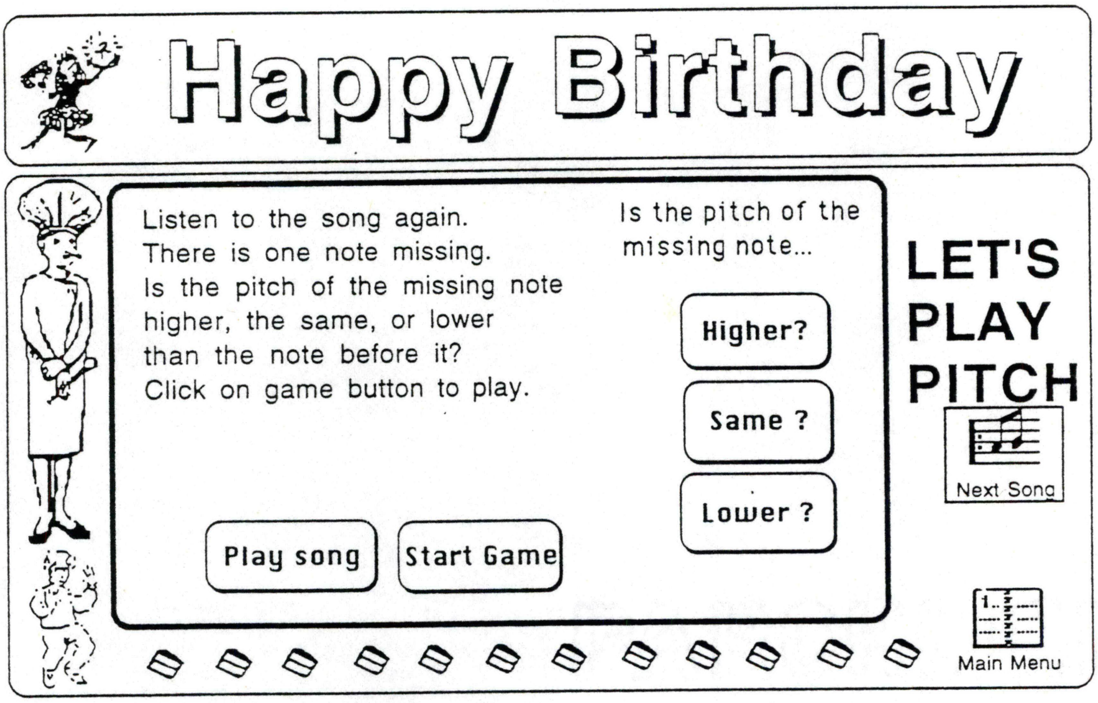

Figure 6. Song card (Happy Birthday). Activity for "Let's Play Pitch".

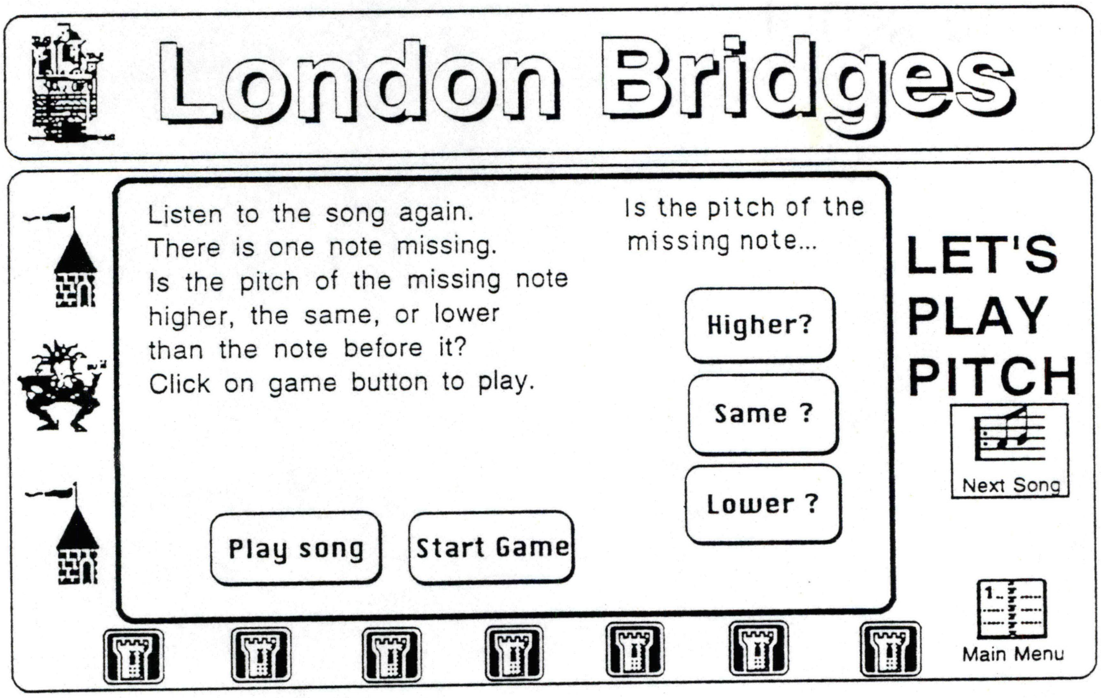

Figure 7. Song card (London Bridges). Activity for "Let's Play Pitch".

The third activity "Pitch Challenge" (see Figure 8) appears when the user clicks on the "Pitch Challenge" button of the main menu card. The user is given instructions on how to use this card. The student selects a song to play by clicking on the song title buttons under "Play a Song".

The object of this activity is for the student to play the songs on the guitar by clicking on the notes on the guitar neck. The location of the notes represents low and high pitch as the user moves up and down the neck of the guitar. The user applies concepts learned about string length and tension to produce high or low pitch. Although it is preferable that students be able to play the notes without assistance, an on-line help is provided to enable them to do so. The user may view the notes to the songs by clicking on the "Notes to Songs" button.

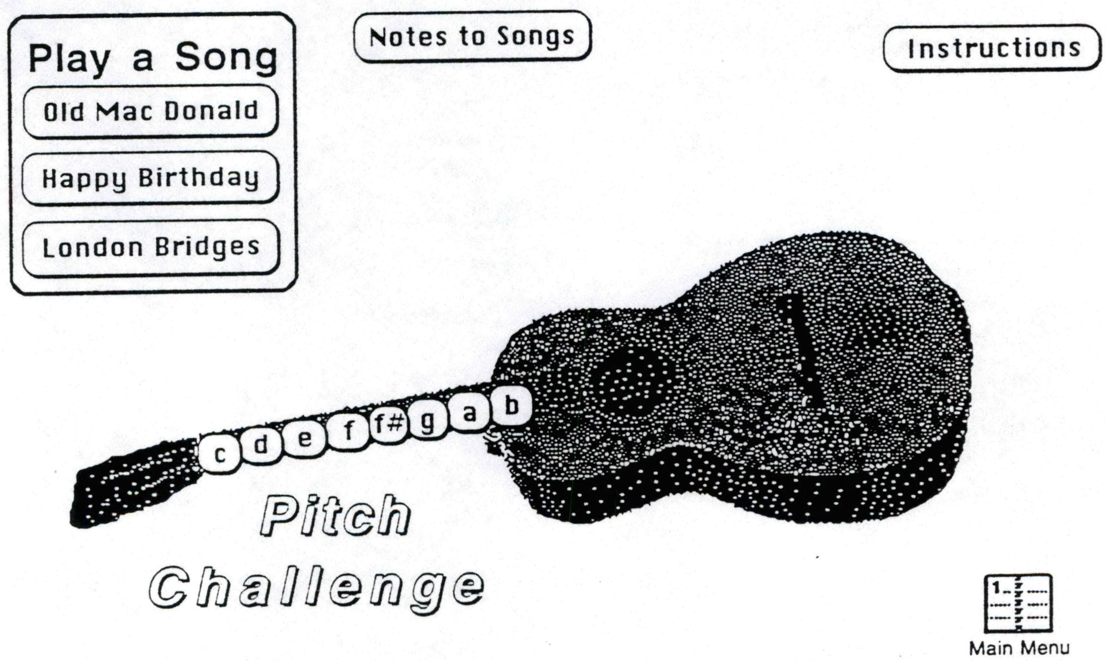

Figure 8. Pitch Challenge. The third learning activity.

Formative Evaluation

This software was evaluated by six students in the third grade. High school students and teachers also evaluated this software. As suggested by Dick & Carey (1985), this evaluation was done on an individual (one-on-one) and a small group basis. The purpose of this evaluation was to determine if the program is grade level appropriate and to check to see if the intended users can navigate through the program with a minimum of interaction with the teacher. The final stage of formative evaluation would be to conduct a field trial using a group of about thirty students (Dick, & Carey, 1985). The equipment used for this evaluation was a Macintosh IIsi computer with an Apple desktop bus mouse and a twelve inch RGB monitor.

Results of Student Evaluation

The first thing that both the third grade students and the high school students noticed and mentioned about this project was the dinosaur on the opening screen. It captured the attention of the third graders right from the beginning. The high school students thought it was "cute". They also liked the songs that played at the beginning of each program. The third graders were so motivated by this project that they were not conscious of the fact that they were using a science simulation. In this sense the project became a type of transparent learning tool. They liked the sound and graphics. At the same time, most of them were able to give an appropriate grade level explanation of the concepts of pitch and volume after using the program a few times.

Results of Teacher Evaluation

Teachers liked the graphics and music as much as the students. They could see the advantage of teaching science with a project of this type. They felt that the kids would be learning science concepts while having the fun of playing something like an arcade game. Teachers were more aware of the science content of the project than the students and they felt this type of project would work effectively in their classrooms.

Recommendations & Revisions

One of the problems encountered by third graders was that some of them had poor reading skills. It was necessary for the teacher/evaluator to read the text in the text boxes to these students. The students with third grade level reading skills could read the text boxes but the students in both third grade and high school had problems understanding the directions in the text box on the "More About Pitch" screen. Another problem with the third graders was their lack of computer skills. It appeared that those students who had computers at home were able to use the mouse easily, while those with limited or no experience had to learn how to use a mouse before they could use this project.

Students stated that they thought color screens would be better and they would like to see a lot of animation. Teachers suggested that they would like to see the screens in color and they would like to be able to connect it to a television monitor so that when they demonstrated the program, the whole class could see it at the same time.

Most teachers were not aware that teacher-made projects of this type existed. A few teachers had problems using the mouse. Most teachers were excited about the possibilities of a project of this type, and said they would be willing to work as part of a group in the development of this type of software. As a result of this evaluation the directions in the "More About Pitch" text box were simplified and reworded to make them less confusing to third graders.

How to Use this Project

This software could be used in a science unit dealing with matter and energy. Sound is typically grouped in a unit with force, work, machines and types of energy. The following lesson plan illustrates how the software can be integrated with the activities provided by the science textbook.

Previous Learning in Sound Unit

It is essential that students have learned the following prerequisite skills.

1. The students can identify different sounds such as whistles or hand clapping.
2. The students can discriminate between sounds that one might hear in nature or on a busy street.
3. The students can define sound as a form of energy.
4. The students can explain that sound is produced when matter vibrates.
5. The student can describe how sound moves through the air.

Sample Lesson Plan

This lesson is based on the teacher's edition of the Silver Burdett Science Textbook (Mallinson et al., 1985). It has been simplified and revised to allow the software to be integrated into the lesson.

Objectives

At the end of the lesson the students should be able to:

1. Name two ways that sound can differ (volume, pitch).
2. Define the term volume as the loudness or softness of a sound and the term pitch as the highness or lowness of a sound.
3. Describe the volume and pitch of a sound.

Science Vocabulary

Key terms: volume, pitch.

Motivation

Fill several soft drink bottles with water, each to a different depth. Arrange the bottles in order according to the depth of the water. One at a time, blow across the mouth of each bottle. Ask the students to describe how the sounds are different.

Concept Development

Write the term volume on the chalkboard. Have the students pronounce the term, first by whispering it and then by shouting it. Tell the students that they have demonstrated the meaning of the term. Then ask: **What was the difference between the two sounds?** (One was loud, the other was soft.)

Take a drum or large can and place small bits of paper on top of it and strike it with a drumstick or similar object. The small bits of paper will fly into the air. Then ask: **How do we know that the drum is vibrating?** (The bits of paper are flying into the air.) Lead the students to conclude that the harder the drum is hit, the more it will vibrate. Therefore the sound will be louder than if the drum was hit softly.

Ask a student who plays a musical instrument to demonstrate different notes with the instrument. Then ask: **How were the sounds different?** (Some were high, some were low.) Write the term pitch on the chalkboard. Tell the students that the highness or lowness of a sound is called pitch.

Explain that sounds with a high pitch are caused by a fast vibrations and sounds with a low pitch by slow vibrations. Ask the students to identify sounds with a high pitch and sounds with a low pitch. Point out that two sounds may be the same volume but different pitches.

Introduce the students to the **HyperCard® program** "Name That Pitch" by showing the students how to navigate through the three sections. Then have them "explore" the stack and do more practice on pitch and volume. Have them discover the answers to the activities on their own.

Enrichment Ask the music teacher to demonstrate a pitch pipe. Also ask him or her to demonstrate two sounds with the same volume but different pitches, and two sounds with the same pitch but different volumes.

Reinforcement

Allow students to use the **HyperCard® program** "Name That Pitch" to reinforce the concepts of **volume** and **pitch** that were previously studied in the science textbook.

REVIEW QUESTIONS

Ask the lesson opening question: **How are sounds different?** (In volume and pitch)

Assign appropriate end-of-lesson questions.

Application

Have the students demonstrate how to make the sounds of different volume and different pitch by tapping on various objects with a pencil. Have them classify the sounds as loud or soft, and high or low.

Implications to Learning and Instruction

In the textbooks there are several suggested science experiments that may be done by the students. Before a teacher can complete these activities, they would have to obtain all of the required materials and have the students prepare these materials for the activity. For example, to complete the shoe box and rubber band activity described earlier in this section, the teacher would have to obtain all the boxes and rubber bands and have the students cut the boxes and assemble them. By using computer simulations the students get the experience of performing this type of experiment without having to collect and prepare all the materials.

The basic idea behind this project was to use technology to enhance science instruction and learning. This was accomplished through the following:

1. Feedback (information indicating that a response is right or wrong).

Results from feedback studies have shown that immediate feedback is more effective than delayed feedback and that most forms of feedback are more effective than no feedback. Computer-based instruction provides a more efficient means of implementing and testing different forms of feedback than print-based materials (Anglin, G.J. 1991).

Immediate feedback is given in several areas of this stack. For example in the "More About Pitch" section there is a check answer button that allows the learner to check their answers immediately. Another place where immediate feedback is provided is on all of the "Let's Play Pitch" cards. Whenever an answer is selected, a field opens with either positive feedback (information that the learner gave the correct response) if the answer was correct, or (if an answer is incorrect) an explanation of why the answer was wrong and encouragement for the learner to try another song.

2. Positive reinforcement (the strengthening of a behavior by providing pleasant consequences).

Positive reinforcement is closely allied to feedback. Feedback provides the knowledge that a response was correct or incorrect. Positive reinforcement takes two forms. One is to provide the correct answer for the student. This should occur whether the correct answer was given or learner has exhausted the correct number of tries. Feedback and positive reinforcement are often combined in a form like, "That's correct. You knew the answer was _____ ."

The other side of positive reinforcement is praise for a job well done and/or encouragement to continue. Psychologists have conducted much research on various levels and frequency of positive reinforcement, which shows that it is generally better to reinforce on an intermittent (often but not every time) schedule (Woolfolk. A. E. 1995). This research seems to be ignored by course ware developers. By and large, such positive reinforcement is either absent, or it occurs on every item.

One of the forms of positive reinforcement in this stack is a boing sound for each correct answer on the "More About Pitch" card. On the "Let's Play Pitch" cards positive reinforcement is given in the form of the song being played correctly when the correct answer is given. At the same time a field opens praising the student for selecting the correct answer. If an answer is incorrect, a field opens and tells the student what the correct answer was, and encourages them to try again.

3. Gaining attention.

The first step in learning is paying attention. Students cannot process something they do not recognize or perceive. Unfortunately attention is a very limited resource. Students can pay attention to only one demanding task at a time (Woolfolk. A. E. 1995).

In this stack, sound and animation are used to gain attention. An example would be the song "The Yellow Rose of Texas" being played by the dinosaur when the stack opens. Songs are played throughout the stack and flashing text and simulations requiring student involvement keep the student's attention on task. Graphics are provided throughout the stack to enhance screen design.

4. Providing help.

It is important to provide students with help when introducing a new computer-based program. It is very frustrating to be working on a lesson and not to know how to get to the next step, or how to get out of a particular section when the learner wants to quit.

There is help provided in all the sections of this stack. There are explanations about how to navigate through the sections of the stack and how to interact with the individual part of the different sections. There is also a prompt to let the student know when it is time to pick a song. All help is provided at a reading level appropriate to the intended learners' reading ability.

5. Interaction and Learner Options.

By providing options for the learner, they will have the option of learning different things instead of reviewing the same information every time they use a specific lesson.

On the opening card of this stack the students have a choice of going to any one of three different sections. In the "Pick a Song" and "Pitch Challenge" sections they can choose which song or activity they would like to use.

6. Simulation.

The section titled "Pitch Challenge" of this stack is a simulation. This section provides a guitar, and by using the mouse and clicking on the frets in the appropriate places, the student can play "songs" on the guitar. One of the nice features of this stack is that the teacher can add songs to either the "Let's Play Pitch" or the "Pitch Challenge" section. In the "Pitch Challenge" section those songs can be played on the guitar. At this time, the songs in the stack are all at the appropriate level for the intended users. It would require very little effort for a teacher to upgrade the stack for use at a higher grade level .

Other Advantages

1. Simplicity of stack function.
2. The feasibility to create or develop a stack is high.
3. Consideration of the limited time that a teacher has.
4. Instead of gathering materials, everything is stored on the disk.

Limitations & Recommendations

Some of the limitations of this stack are:

1. Only third grade science concepts are included in this stack.

2. There is no color used in this stack.

3. There is only limited use of multimedia in this stack. At the present time the computers and equipment at Reche Canyon School are very old and have limited multimedia capabilities. In the not too distant future the school plans on buying new computers with CD-ROM drives. At that time,

this stack can be reused and supplemented with more advanced technology.

4. Since this stack is a reinforcement tool, previous instruction is required.

5. Children worked on this stack for one half hour. To thoroughly explore the stack would take several half hour sessions.

Conclusion

To effectively meet the goals and objectives of the State Science Framework it will be necessary to make more effective use of the technology that we presently have access to. Students can learn and retain much more from a computer based technological approach to an area of science than they can from a teacher and textbook approach where they are required to regurgitate information for a test. By using the technology that we have now, students can get a much better grasp of the scientific principles involved in a lesson instead of mere memorization and repetition of facts.

A larger sample of students could be used in order to get more feedback on the effectiveness of the program. Another improvement would be to use a newer authoring program such as HyperStudio® to include the use of color in the program.

The challenge for educators is two fold. First to become proficient at using technologies such as HyperCard® to create lessons that can enable learners to learn scientific principles that are relevant in today's world. Second we need to give these technological tools to students to aid them in going far beyond what we have done in terms of creativity and knowledge.

Music Information

Musical excerpts from the following songs were used in this master's project:

1. The Yellow Rose of Texas - This tune was first published in 1853. The author was identified only as "J.K." and it was probably intended for the minstrel stage (Agay, 1975). It was popularized in 1928 by Mitch Miller and his orchestra and chorus (Jacobs, 1994).

2. Old Mac Donald - This is a Traditional English-American Song (Hart,1982). It was written in 1917 by an unknown author (Jacobs, 1994).

3. Happy Birthday To You - The words to this song were written in 1893 by Patty Smith Hill. The music was written by Mildred J. Hill (Jacobs, 1994).

4. London Bridge - This is an English Traditional Singing Game. It was written in 1744 by an unknown author (Jacobs, 1994).

Copyright Considerations

The Copyright Act of 1976 extends protection of works to a total of 75 years (Woody, and Woody, 1994). After that time the works become public domain. Since these songs were all written before January of 1920, they are no longer protected by The Copyright Act.

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