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Use of a computer based instruction program to enhance desert study kit concepts

Dean Aurelius Von Wald

USE OF A COMPUTER BASED INSTRUCTION PROGRAM TO ENHANCE DESERT STUDY KIT CONCEPTS

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

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by

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ABSTRACT

This project was designed to address the need for enriching a hands-on learning material presented by the San Bernardino County Museum. A supplemental computer based instructional program was created to help improve students' understanding of the Desert Habitat Study Kit. The goal of the project was to implement activities which contribute to students' problem-solving abilities, as well as deliver instruction through a medium which applies multimedia technology.

Utilizing the animals and insects represented in the Desert Habitat Study Kit, several stacks were developed by this author with the learning objective of teaching students about desert animal adaptations. The project was tested and evaluated with two third grade students.

Theory and practice surrounding computer design principles for instructional programs was studied by this author. The theory of "hierarchical learning" was applied into the project's design, including the use of multimedia technology to help promote problem-solving skills in students. Content objectives of the project were in alignment with the goals prescribed by The California Science Framework (1990) for students in the third grade and were based upon the Framework's theme of "Systems and Interactions".

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Grateful appreciation is given to Dr. Rowena Santiago for her continued support and encouragement throughout the development of this project. Thanks also to the staff and friends at Kimbark Elementary for the comfort in knowing that they were always nearby in time of need.

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CHAPTER I

Introduction

In 1990 a movement towards building scientific literacy in students was brought to the public's attention through a presidential science advisory council (Gershon, 1990). This council was formed in the wake of a growing number of trends showing declines in students' math and science scores. In response to the call for reform in science education, educators looked for alternative teaching methods which would help raise students' science literacy (Gershon, 1990; Hill, 1993). In accordance with the California State Board of Education's Science Framework for California public schools (1990), some educators recognized the use of hands-on materials as one approach for significantly improving science instruction (Chaille & Britain, 1991).

Today, educators employ the use of hands-on experiences in the classroom as a feasible application towards increasing the potential of their science instruction (Chaille & Britain, 1991). Lopez & Tuomi (1995) acknowledged this and explained the following:

> ...the best way to accomplish (learning) is to examine natural phenomena that are brought into the classroom and studied over time. Active, hands-on, student-centered inquiry, in which kids learn to apply

scientific problem solving, should be at the core of science education (p.78).

In addition, the inclusion of hands-on experiences in any learning circumstance creates situations that embody the work of several learning theories (Bybee, 1993; DeVries & Zan, 1994). Based upon the Piagetian model of learning for "concrete thinkers", Metz (1995) added support for the need of hands-on materials to address young students' science needs, and called for a higher presence of hands-on materials in science instruction.

In their book, Really Raising Standards, Aday & Shayer (1994) discuss the importance of building a child's cognitive development through concrete experiences and exposure to programs which promote understanding and facilitate higher level thinking skills. Both authors state that without these skills "children will not be able to handle the high level and flexible thinking required in twenty-first-century employment using concrete operations" (p. 182). The challenge for teachers, therefore, is to create learning opportunities using hands-on materials that prepare students for the future.

How can hands-on learning affect the objectives of science instruction? Can technology be used to address concerns present in the area of science instruction today? This project will answer these questions through the development of an instructional material that utilizes a hands-on learning science kit to teach desert animal adaptation concepts to young students.

Statement of the Problem

<u>Advantages and Disadvantages of Hands-On Instructional Materials</u>

The summon for reform in methods practiced in science instruction has encompassed a time frame of over four decades (Bybee, 1993). Since the era of "Sputnik" in the 1950's, a push towards improving science instruction in our schools has become one of the popular issues raised in educational reform (Brill & Larson, 1995; Gershon, 1990; Hill, 1993; Massell & Searles, 1995;).

A restructuring of the curriculum, and an overhaul of teaching strategies where "scientific knowledge was the dominant aim" (Bybee, 1993, p. 12), gave way to a national outcry for scientifically savvy students. Even though the efforts toward reform in science instruction have not been thoroughly implemented (Jacobs, 1996), some educators view the use of hands-on materials as an approach for improving science instruction and developing critical thinking skills in students (Chaille & Britain 1991; Jacob, 1996; Lopez & Tuomi, 1995; Van Horn, 1995).

Exploration and hands-on learning have long enabled science instruction and assisted the techniques in which teachers design their lessons (Lopez, 1995). Chaille and Britain (1991) regard hands-on materials as devices that actively engage students in constructing knowledge. As Constructivists, they contend the importance of hands-on experiences in the classroom because "learners do not acquire knowledge that is transmitted to them; rather, they construct knowledge through their intellectual activity and make it their own" (p. 11). Furthermore, the inclusion of hands-on materials into instruction enhances the educational setting and provides relevant learning opportunities that encourage inquiries and investigations (Lopez & Tuomi, 1995; Van Horn, 1995).

Yet, the debate for how to make the best use of hands-on materials continues to be a focus of concern among educators (Flick, 1995; Metz, 1995). Whereas some concerns are centered around the need for more funding to purchase meaningful science materials ("When the Subject is Science", 1990), Chaille & Britain (1991) see problems in using hands-on materials to assess learning outcomes.

> The hands-on nature of activities is an important part of (the) curriculum...With young children, physical activity and manipulation is often a necessary part of mental activity, but not always...Children need to be active, and they need opportunities to manipulate and experiment

with real objects. But this in itself is not the definition of a good activity (p.19).

Means for changes in the application of hands-on materials is stemmed from the belief that "in science classes...even hands-on activities do not alleviate the need for students to make reality checks between what they are experiencing and thinking" (Flick, 1995, p. 1067). Thus, the aim of hands-on materials should be to create a learning format which is selective and uses objects as keys for addressing problems; or utilizes objects as an approach for motivating students towards concepts which promote learning objectives and higher-order thinking skills (Metz, 1995). Yet, defining manageable solutions for how to effectively incorporate hands-on materials in science instruction are not always easily ascertained (Flick, 1995; Metz, 1995; Van Horn, 1995).

The Need for Improving Hands-On Learning Materials

An impressive source of science-related activities and hands-on materials in San Bernardino is the County Museum. This local archive recognizes the importance of creating partnerships with educators and offers a variety of programs to enhance curriculum instruction. In addition to being a site for educational field trips and hands-on learning experiences, the County Museum extends its resources to schools through a learning outreach program. This program was established as a method for bringing substantial museum materials into the classroom.

Educators within the San Bernardino County can choose from a series of educational study kits to apply in their instruction through the museum's study kit loan program. The study kits are identified by different habitats within the San Bernardino region. Each habitat study kit contains a number of preserved plant and animal specimens for hands-on interaction, a notebook containing background information for the plants and animals in the kit, outlines for different activities, and supplemental materials (ie. VHS tape, books and brochures). The provision of concrete experiences, such as observation and classification, prevail as the learning objective in the study kits.

The interpretive specialist and outreach education coordinator for the San Bernardino County Museum is Jolene Redvale. Among many of her duties is the responsibility of overseeing the creation and implementation of the study kits into the county's school districts. She reviews and evaluates user responses of the museum outreach program and has found that even though the study kits present motivating and interesting subjects for inquiry and investigation, many teachers have trouble using all of the hands-on materials and follow-up activities in their classrooms successfully. She reports that some users of the study kits claim they lack meaningful instructional materials which provoke young students to apply abstract thoughts in their thinking. She has also found that the follow-up activities and lessons in the study kits are not always in alignment with the content, and offer few opportunities for students to engage in problem-solving activities or lessons which relate to the hands-on materials.

Ms. Redvale concludes that the study kit's problems are a result in the under staffing of the program's personnel and budgetary shortcomings. In essence, the design of the study kits follow the argument offered by Metz (1995) in that they "largely restrict children's science curricula to concrete and hands-on activities, and postpone abstractions until higher grade levels" (p. 103). Based upon a failed instructional follow-up, the study kits support explanations offered by Yager and Lutz (1995) that "even hands-on activities are generally set up to put students through a series of technical manipulations" (p. 31). Consequently, when using the study kits in the classroom, students are rarely given opportunities to develop problem-solving skills. The focus purpose of this project will be to address the need for improving the instuctional value in the Desert Habitat Study Kit.

Addressing the Problem Through Technology

The traditional view towards science from students is largely negative (Yager & Lutz, 1995). Most people hold unpleasant feelings towards science instruction because "of the way science teachers advanced their objectives and intentions in their courses and their instruction" (p. 28). However, the advent of technology has helped improve the application of science instruction in many classes. Freitag (1993) believes the importance of technology inclusion in the science curriculum comes through the proper training of teachers. He stated the following:

> Informing and participating in the development of new teaching and learning resources have always been important avenues for scientists and education researchers to contribute to K-12 science education. Modeling innovative ways of teaching and learning with and from technologies will be an important aspect of preparing science teachers for (technological) learning environments (p. 90).

The presence of technology in the classroom has helped establish appropriate methods for improving curriculum (Jenkins, 1990); and deals with constraints that dominate issues surrounding science instruction, such as motivation and the promotion of vital problem solving skills. Yager & Lutz (1995) stated, "more than half of the students in elementary schools like science, but by the time students reach high school, the number of students who like science decreases to only one-fourth" (p. 28). Much of this can be contributed to an antiquated system for instructional science procedures and a lack of motivation towards science by students (Gershon, 1990).

The objective for science teachers, especially in the elementary grades, is to redefine techniques which can enhance science instruction so that it is stimulating and motivational for young students. The integration of technology into science instructional plans is seen as a viable method for improving student response and learning (Bransford, et. al., 1990; Lehman, 1994; Lengel & Collins, 1990). Technology related science instruction is shown to improve student attitude towards assignments and focus students on to problem-solving situations (Raphael & Greenberg, 1995). Even more, the involvement of technology in science instruction demonstrates "that kids are drawn to technology and intrinsically motivated to use computers" (Guthrie & Richardson, 1995, p. 16).

The request for reform in science instruction has several thrusts including the integration of technology and hands-on activities (Reynolds, 1993). In the School of Education Review (1993), a special issue centered on reforms in science education, K-12, it is noted that the integration of technology in science programs benefit students progression for developing positive attitudes toward science and skills in scientific thinking (Reynolds, 1993).

Kathleen Metz (1995) recognized that the establishment of science thinking skills at an early age is an important factor in the development of young children, and that the purpose of technology takes on a meaningful relationship with science instruction. Technology plays a crucial role in transforming the learning environment for the young child (Jenkins, 1990), and its purposeful implementation into the science curriculum is "beginning to have an effect on society's definition of good education" (Bradsher, 1990, p. 317). Therefore, given its motivating power and useful application in the area of science, technology presents creative solutions for improving science instruction, assisting the development of problem solving skills, and regaining direction towards instituting science literacy in young students.

As mentioned, there is a great need for specific changes in the way science is being taught to students. Focused and directed use of hands-on materials, motivational techniques to capture student attention, and integration of technology into science instruction are essential requirements in the plans for rebuilding science literacy in students.

Significance of the Project

Establishing Collaborations

Another push in the reformation of science instruction has been in the movement of developing partnerships with those who can provide expertise in science-content related fields (Brill & Larson, 1995; Bybee, 1993; Massell & Searles, 1995). The benefits of science partnerships help promote involvement and the use of additional materials otherwise unavailable to educators (Massell & Searles, 1995). These types of instructional settings also unveil interactive, hands-on learning situations which are conducive to learning that is investigative by design (DeBruin, et. al., 1993).

An important aspect of this project will be its association with the County Museum and partnership with an institution known for supporting educational concerns. In addition, this project will address the instructional concerns surrounding the Desert Habitat Study Kit offered through the San Bernardino County Museum Educational Loan Program, and develop a software program that represents the study kit content in a suitable manner following computer design and learning principles.

Providing Technology and Hands-On Resources

A system where students can develop critical thinking skills and science knowledge through themes which connect learning to a new model of instruction has helped the transformation of science education (Bybee, 1993). Bybee (1993) explained these changes of attitudes towards science instruction as a movement from a text-driven curriculum to one where hands-on learning and direct experiences dominate instruction. Yager & Lutz (1995) support the significance for having a clear instructional direction in the use of hands-on materials and a focus of science process skills such as critical thinking and problem solving.

This project will be aimed in defining the instructional power of combining two science-related motivational devices: technology and hands-on materials. Furthermore, the project will be in alignment with the California State Board of Education's Science Framework for California public schools (1990), and provide information specific to the learning requirements defined in the framework for Life Sciences.

Project Overview

This project will design and create a computer based instructional program for the Desert Habitat Study Kit. The study kit is a hands-on instructional material offered to school teachers in the county through an educational loan program from the San Bernardino County Museum. The audience for the project will be elementary school children in the third grade. Using the grade level theme "plant and animal adaptations," the project will be specifically designed to assist students in using problem-solving skills for understanding the adaptive traits and qualities of the desert animals and insects.

Students will be presented with background information concerning the diet, habitat and adaptive features of each of the animals and insects presented in the Desert Habitat Study Kit. Students will also have the opportunity to apply their knowledge about each of the animals and insects through several "Activities" in the project. The project will support the content of the study kit, and challenge students in the third grade to incorporate problem-solving skills into their responses.

Utilizing material from the County Museum's Desert Habitat Study Kit, this project will use the personal authoring software program *Hyperstudio* for developing instructional material. The design and navigational strategies of the project will follow the computer programming principles recommended by Gagne, et. al. (1992) and Overbaugh (1994). Multimedia techniques will be employed to enhance the instructional goals of the project. Graphic images, sound and text will add features which help direct the student through the program.

CHAPTER II: LITERATURE REVIEW

Preview

The evolution of science instruction and technology have worked to change the processes of learning among students in education. Proponents of technology see benefits in its application towards science instruction and other areas of education. Roger Bybee (1993) writes, "Science and technology are recognized as lying at the center of the current shifts in our society" (p.ix) Yet, some critics raise questions on the purpose of technology and its effectiveness in promoting learning in the classroom. Guthrie & Richardson (1995) state, "Simply placing computers into classrooms isn't going to change teaching and learning; it will not reform schools" (p.17).

One certainty is that the presence of computers and other forms of technology in the classroom setting are growing (Khalili & Shashaani, 1994; Reynolds, 1993). Even more, a growing concern among educators is the preponderance of evidence which suggests that students will not be adequately prepared to meet the demands of the twenty-first century using the skills they have (Gershon, 1990). Educational researchers Jungwirth & Dreyfus (1990) examined the history of science instruction and found that among the basic elements of instruction, the development of critical thinking skills in students was one of the most regarded among science educators.

The impact of technology on the learning process, and how can it be effectively used to compel problem-solving skills in students is reviewed in this chapter. In addition, learning theories which suggest relationships between higher order thinking skills in young students, and design principles for computer based instructional (CBI) programs, are covered. Active learning theories for young students and approaches in hands-on experiences in science instruction are also be studied.

History and Trends in Science Instruction

The history and evolution of science education in American schools is comprised of a comprehensive and vast time period of societal and technological changes (DeBoer, 1991). Beginning with the influence of European educators in the late nineteenth-century, a Swiss educator named Johann Heinrich Pestalozzi made popular the theory of "sense impressions, experimentation, and reasoning" (p. 22). Pestalozzi's approach to teaching was premised on the belief that children achieved greater understanding of their world through experience-based learning that was in "harmony with the natural development" of the child, rather than through the traditional methods of memorization and passive listening (p.22).

Paul Saettler (1990) described the influence of Pestalozzi through his teaching programs which "brought life closer to the learner, replaced drill with observation and learner motivation and respected the individuality of each learner" (p.39). Deboer (1991) believed Pestalozzi was a pioneer in defining the changing roles of the teacher, from an inert evaluator to an active facilitator, which enhanced the process of science instruction. However, many of his theories were refined and changed by European educators, and never were fully interpreted in the spirit defined by Pestalozzi.

Another European educational ideologist was Johann Freidrich Herbart. Deboer (1991) stated that Herbart's impact on science education was founded in the assumption that a child's "conceptual understanding" could be developed through interest and feelings towards the environment. Yet, Herbart also believed childrens' learning occured through their discoveries which were based upon pre-conceptualized learning. DeBoer (1991) stated:

> It was better if the child could discover the relations between natural phenomena because that would produce a fuller and more meaningful understanding of the concept. The teacher's role

> was to provide guidance through skillful questioning, not simply to state the principles or rules (p.27).

Both Pestalozzi and Herbart were viewed as science visionaries and would be the impetus towards changing science instruction for years to come.

In American elementary schools in the early twentieth-century, according to Bybee (1993), the basis of science instruction could be defined in two ways: "One was a knowledge-oriented model referred to as 'elementary science'; the other was nature study and had personal development as its primary aim" (p.8). Both models emerged from the era of changes in the industrial and technological workplace, and were developed to maintain the balance between work sectors in the agriculture settings and cities.

Bybee (1993) explained that as the influences and interests of both societies' clashed, many of the reformations and focuses towards science education in the early twentieth-century shifted to the secondary level of instruction. He also wrote of changes in science instruction which were based upon John Dewey's aim of "reflective thinking". Dewey's popularized "scientific method" was a reflection of the historical issues during that time period and satisfied Bybee's explanation:

> During the period from 1920 to 1940, the knowledge model of secondary science continued to dominate science curriculum...The knowledge model

> reflected a back-to-basics posture often associated with times of economic austerity...the emphasis on scientific methods was an educational manifestation of the need to solve many social problems of the time (pp.11-12).

The reorganization of science education continued its progress up into the middle of the twentieth-century where "it was widely believed that science education should be related to the real-world experience of students, especially to those things that interested the students" (DeBoer, 1991, p.83). Whereas most of the discussions concerning science education were relegated to the domains of secondary and post-secondary educational settings (Bybee, 1993; DeBoer, 1991; Gershon, 1990), the mid-1950's brought with it a progressive movement towards curriculum reform in the wake of the launching of "the earth-orbiting satellite Sputnik in 1957" (DeBoer, 1991, p.147).

One institution known as the National Science Foundation (NSF) funded several programs aimed at improving science instruction throughout America's schools. One of the programs funded by NSF was Elementary Science Study (ESS). Raizen & Michelsohn (1994) defined coursework in ESS as being instruction which "emphasized independent exploration of science phenomena by children" (p.158). These programs helped develop packaged science "units" which emphasized "both broad organizing concepts and inquiry skills" for young students (Raizen & Michelsohn, 1994, p. 88).

Grossen & Romance (1994) believe current practices in science education are instructively controlled and dictated by textbooks. They write that many science textbooks have been criticized by educationalists for containing too many vocabulary concepts, being unclear and unable to effectually promote change. In response to these concerns, curriculum reformists in California have begun to realize that teachers and students need better instructional materials with "different learning formats for different learning styles; (and they are supporting the movement) away from the textbook as the most important learning tool" (Hill, 1993, p.20-21).

However, Yager & Lutz (1994) suggest that the action towards science reform should be focused not on what we teach, but how we teach. Educational researchers agree that steps to improving science instruction should be modeled after what we have learned from current research on human learning processes (Tomic, 1994; Wang & Sleeman, 1994; Yager & Lutz, 1994).

Cognitive Research and Science Instruction

The continued reshaping of science instruction was motioned by the writings of educational psychologists Jean Piaget, David Ausubel and Robert Gagne from the 1960's to the present (DeBoer, 1991). These cognitive psychologists greatly impacted and framed the methods for which children would be taught in the remaining years.

Piaget's influence upon science education suggested childrens' perceptions are strongly determined by their mental and physical maturation and can be identified by a seriation of events in their lives (DeBoer, 1991; Metz, 1995). DeBoer (1991) explained that "since the mental structures are relatively stable and not easily changed, it follows that students should be presented with material that matches their level of cognitive development" (p. 197). The need for science instruction to be modified to fit the intellectual precepts of the child became the "framework for transforming science instruction into a developmentally appropriate form" (Metz, 1995, p.95).

Ausubel's perception of learning constituted a didactic approach to instructing new concepts for young students. When applied to science instruction, the Ausubellian theory requires a receptive and passive learner "in which concept labels and the regularities they represent are taught explicitly by the teacher" (DeBoer, 1991, p.202). New knowledge is gained from directed learning rather than "discovery based" learning approaches manifested by Pestalozzi, Herbart and Dewey.

Like Ausubel's "receptive" learning method, Gagne's theory of learning, called "hierarchical learning", is largely based upon the understanding that new knowledge is achieved through an "acquisition of specifically learned rules" (DeBoer, 1991, p.204). A learning objective is taught using a set of prerequisite skills and steps which guide the student to gaining an intellectual skill (Gagne, et. al., 1992). The complexity of Gagne's theory can be carefully planned into a series of events which effect the outcome of instruction.

Gagne's Events of Instruction

Chaille & Britain (1991) find that the young child is an inquisitive and active learner requiring a curriculum model which provides "guidance by creating learning situations that allow and encourage diversity" (pp. 24-25). In essence, Gagne's "hierarchical learning" stages plans a course of instruction which facilitate learning in any situation, be it passive or active. Gagne, et. al. (1992) state:

> The purpose of instruction, however it may be done, is to provide support to the processes of learning. It may, therefore, be expected that the kinds of events that constitute instruction should have a fairly precise relation to what is going on within the learner whenever learning is taking place (p.186).

When applied to science instruction, Gagne's steps of "instructional events" accentuate the learning process through steps which "are designed to make it possible for learners to proceed from where they are to the achievement of the capability identified as the target objective" (Gagne, et. al., 1992, p.189). The following presents an outline in which Gagne, et. al. (1992) detail the stages within the theory for instructional events. Each event is supported by the proceeding step and effects the outcomes of learning.

1. Gaining Attention

* Involves the use of stimulus changes.
* Focuses the learner and gains attention.
* Can be determined in a variety of methods ranging from sound bites to visual cues.

2. Informing the Learner of the Objective

* Activates the process of "executive control".
* Communicates the lesson objective to the learner.
* Translated in a form which is understandable by the student.

3. Stimulating Recall of Prerequisite Learned Capabilities

* Retrieval of prior learning to "working memory".

* Combines new ideas with previously learned skills or ideas.
* Recognition skills can be motivationally recalled.

4. <u>Presenting the Stimulus Material</u>

* Emphasizing features for "selective perception".
* Establishes discriminations to assist the student in identifying distinguished objects.

5. <u>Providing Learner Guidance</u>

* Stimulates the direction of thought.
* Provides cues which help the student retrieve previously learned materials, and then combine these concepts to formulate new rules or ideas.

6. <u>Eliciting the Performance</u>

* The activation of a response by the student.
* The "show me" or "do it" stage of learning.

7. <u>Providing Feedback</u>

* Provides information to the student about his performance.
* Establishes reinforcement of learned skills.

8. <u>Assessing the Performance</u>

* An assessment of learning outcomes.

* Students activate their retrieval skills for observation by the teacher.

9. Enhancing Retention and Transfer

* Providing cues and strategies for retrieval.
* The concepts and rules are spaced at intervals and varyingly exercised (Gagne, et. al., 1992).

DeBoer (1991) upheld the theory of "hierarchical learning" as a reflection of the principles defined in "receptive learning" theory. He explained both approaches as being founded in principles that are "in contrast to discovery learning, in which regularities are discovered by the students themselves" (p. 202). Therefore, the cognitive theories of Piaget, Ausubel and Gagne can be viewed as providing methods of instruction in which the acquisition of learned skills is presented in small, structured segments (DeBoer, 1991; Gagne, et. al., 1992; Metz, 1995).

In their book, The Future of Science in Elementary Schools, editors Senta Raizen and Arie Michelsohn (1994) discuss the importance of a teacher's understanding of learning principles defined by educational psychologists, and the application of this knowledge in their instruction. Accomplished science educators know "that old theories of learning based on the accumulation of factual information have given way to more complex theories of conceptual development...and that their students need many concrete experiences before they can understand scientific concepts" (p.33).

DeVries & Zan (1994) also discuss the importance of serving childrens' intellectual needs by providing "for activities that stimulate their interests and provide content that inspires them to figure out how to do something" (p.59). The role of the teacher as a science instructor, therefore, reissues the conflicts of different instructional theories where "science educators have the endless task of reformulating purposes, renewing policies, redesigning programs, and revising practices" (Bybee, 1993, p. 71). Thus, the main focus of science instruction needs to be centered on the belief that "learning happens when an involved learner confronts his or her current understanding of a concept and actively works to construct a new or better understanding" (Raizen & Michelsohn, 1994, p.52).

The California Science Framework

The organization of a curriculum around unifying themes was developed over a century ago when American educator Charles DeGarmo "concluded that the coordination of individual courses in the curriculum was a better idea than the attempt to correlate all knowledge with respect to some overarching principle" (DeBoer, 1991, p.28). His thoughts on unifying themes were constructed around the understanding that young students would be readily able to make "easy associations" with the principles of relevant subject matter, and then build upon this knowledge as they progressed and matured through their education (DeBoer, 1991).

Today, themes in science are designed as guides for classroom activities, and assist the structuring of lesson content so that learned skills will have a conceptual link to an underlying theme (California Science Framework, 1990; DeVries & Zan, 1994). According to The California Science Framework (1990), the purpose of presenting content areas of study for students, is "to avoid an emphasis on isolated facts and definitions that have long dominated science instruction" (p.3). Kneedler (1993) states that a central purpose of the Framework is that

> ...students should be actively learning the 'big ideas' in science. Active learning is described by the Framework as students actively processing information revealed to them in direct experiences, such as hands-on laboratory experiences, reading and listening, collaborating with peers and learning new technologies. In each case, the student has the option to manipulate some aspect of the learning experience (p.74).

The Framework also establishes the concept that "certain ideas transcend disciplinary boundaries and are essential to understanding intellectual relationships among all the disciplines of science" (Raizen & Michelsohn, 1994, p. 64).

The California Science Framework (1990) is subdivided into six major themes, one of which is titled "Systems and Interactions". Within the traditional area of life sciences (chapter five), students in grades three through six are introduced to concepts pertaining to living things and "their adaptions to their environments and their ways of life" (p. 119). One relationship this project will have with the framework is the underlying theme "that living things have structures that do specific things to help the organism live and grow and meet their needs as they interact with their environments" (p.118).

Hands-On Activities in Science Instruction

Jerome Bruner helped promote the use of hands-on materials in the 1960's with the belief that "children must first learn by using real objects, then pictures of real objects, and only then symbols for objects" (Van Horn, 1995, p.786). Based upon his theory of cognitive development, Bruner identified rules "by which an individual copes with his environment" (Saettler, 1990, p.331), and prescribed the notion that instructional materials should not be selected in terms pertaining to their connection to content, but should be chosen based upon "their ability to develop the processing skills that make up such an important part of human intelligence" (Saettler, 1990, p.440).

In the 1970's research concluded that the use of hands-on materials in science was an appropriate substitute for instruction over textbooks (Lopez & Tuomi, 1995). The NSF supported the creation of study materials utilizing hands-on instruction which ultimately led to the development of the Elementary Science Study program (Lopez & Tuomi, 1995; Raizen & Michelsohn, 1994). Even today the continued request for more hands-on involvement and activities exists in science courses (Jacobs, 1996). However, researchers question the directive purpose of activity-based instruction and call into speculation the limitations hands-on materials create during instruction (Flick, 1995; Grossen & Romance, 1994; Metz, 1995; Tomic, 1994; Yager & Lutz, 1995).

Even though hands-on materials have seen a resurgence in popularity, they have come back "with a new emphasis on quality 'minds-on' as well as hands-on" (Yager & Lutz, 1994, p.340). This "new emphasis" has come about as a result from some of the misconceptions students have when using hands-on materials. Educational researchers Grossen & Romance (1994) challenged the effectiveness of hands-on materials and stated:

> Hands-on learning is not always relevant. It is often impossible to design relevant hands-on activities that effectively communicate underlying explanatory big ideas; for example students would have difficulty figuring out a reliable theory of electricity from a pile of wires...and without coherent, explicit instruction (hands-on materials) can easily lead to misconceptions. (p.450).

Grossen & Romance (1994) suggest that when the concept of texture is not the key to learning, hands-on materials seem to misguide students from the initial objective of the lesson, and therefore only should be utilized when they are relevant to the concept being taught. Conversely, educational reformists Yager & Lutz (1995) acknowledge that hands-on materials are useful in replacing the failed textbooks and their attempts to create relevance for students, however they concede that hands-on activities often stifle students' abilities to discuss theories traditional experiments produce.

Kathleen Metz (1995) discussed the frequency with which hands-on materials are used in the elementary setting because of their focusing power on the processes of observation, ordering and categorization. Based upon the Piagetian assumption that primary school aged children are "concrete thinkers", Metz critiqued the belief that "children's science needs to mainly consist of 'hands-on' activities" (p.95), and that young children need to postpone abstractive thoughts until older. Lawrence Flick (1995) also supported the thinking that hands-on activities in the classroom should have direction towards helping young students' reflective thinking skills. She sited research by Fleer (1992) which contained that the most successful hands-on activities were those that "provided many opportunities for the expression and extension of children's thinking about the scientific phenomena they were investigating" (p.1067).

The philosophy of hands-on materials has evolved from a misguided approach for enhancing science instruction to a focused and structured presentation of materials (Tomic, 1994). Even more, it has helped vitalize the core of science education and become a process for "active...student-centered inquiry, in which kids learn to apply scientific problem solving" (Lopez & Tuomi, 1995, p.78).

Developing Problem-Solving Abilities in Young Students

Sherry Meier, et. al., (1996) defined problem-solving as "the process used to obtain a solution to a perplexing question or situation" (p.231). The emphasis towards producing critical thinking skills in the nation's students has helped create an abundance of definitions pertaining to the word "problem-solving" which are ideally the same, and "are of paramount importance, as are being able to connect knowledge to other information, and communicate that knowledge effectively" (Meier, et. al., 1996, p.230). Norris, et. al. (1992) see an interchangeable relationship between the terms problem-solving, critical thinking, reasoning, logical thinking and higher order thinking skills; in which all "refer to a person's ability to analyze a problem situation and come to an appropriate conclusion or solution" (p.329).

However defined, for more than 100 years problem-solving ability has been viewed as one of the most essential objectives of science education (Jungwirth & Dreyfus, 1990). Furthermore, the possession of sound problem-solving abilities is foremost in what many employers in society look for in their potential employees (Brill & Larson, 1995; Meier, et. al., 1996). However, in today's schools many students are failing to meet the objectives of attaining problem-solving skills and are turning away from curriculum areas, such as science and mathematics, that would help them develop and achieve these skills (Brill & Larson, 1995; Gershon, 1990; Meier, et. al., 1996). Many researchers feel that the matter of constructing educational programs to address the issue of strengthening students' problem-solving skills should be studied and investigated as early in young children's education as possible (Jungwirth & Dreyfus, 1990; Meier, et. al., 1996).

Metz (1995) supported the importance of providing science curricula that induces young students to exercise abstractive thought in their thinking, and disagreed with the theories of Inhelder and Piaget (1955/1958) that "prior to adolescence and the advent of formal operational thought, children lack control to rigorously guide their experimentation and...(cannot) engage in systematic experimentation" (p.111).

Metz (1995) found support for the theory that young children, in a limited manner, understand abstract thinking and therefore should require the opportunity to formulate problems and interpret their inquiries. She concluded that changes in science curricula need to be produced to foster the development of critical thinking skills in young students, and unless students begin to participate in scientific inquiry at a young age, they will impoverish their abilities to develop thinking skills prescribed by the demands of the twenty-first century. Meier, et. al. (1996) also supported the need for curriculum reform and believed "curriculum developers and publishers must recognize the need for interdisciplinary programs that focus on problem solving" (p.233).

Terry Salinger (1992) recognized that "children are interested in knowing long before they enter school and strive to understand abstractions about numeracy and literacy as part of their explorations of the world" (p.322). He explained the concept of "scaffolding" as a teaching method for assisting young children through the process of learning difficult material, and attributed the theory of "thinking scaffolds" which allow young students to:

* refine emerging hypotheses;
* clarify misconceptions before they become habituated;
* provide new information when it is needed to clarify and extend emerging hypotheses; and
* motivate children to extend their thinking and stretch to new understandings and mastery of skills (Salinger,1992).

The benefits of thinking scaffolds are found in the connectivity between the learner, teacher and the "concepts and skills learners are attempting to master" (Salinger, 1992, p.324).

Systematic problem-solving found its origins in the theories of Dewey (Maiorana, 1992; Metz, 1995) when there was a "call to teach science to children in a way that emphasized method over content" (Metz, 1995, p.95). Research suggests that in today's classroom the problem-solving activity is "most effective when used to address problems in a field with which the student already possesses some knowledge and understanding" (Maiorana, 1992, p.47). Meier, et. al. (1996) suggest "learning theory reveals that students learn best what makes sense to them, and what is important to them" (p.233).

However, limitations abound in the instructional approaches concerning problem-solving activities (Maiorana, 1992; Metz, 1995). Maiorana (1992) identified several limitations in the approaches towards problem-solving activities and found that:

* the problem-solving method requires that students understand the problem-solving process;
* problem-solving requires existing knowledge of the subject matter in which the problem is framed; and
* by being presented with ready-made problems to solve, the student does not engage in problem-posing, an essential aspect of critical thinking (Maiorana, 1992, p.47).

A method of action in addressing these limitations can be found in Gagne's stages of "hierarchical learning" (Metz, 1995). Metz (1995) described the stages of "hierarchical learning" as a process in helping science educators implement the scientific theories of Dewey. Metz stated, "The framing of concrete versus formal operational thought provided a way to think about the emergence of Dewey's scientific method, as it functioned as a way to decompose the process of scientific inquiry into a Gagnean learning hierarchy" (p.95). Thus, Gagne's theory of learning lends support to the instructional design of activities and addresses the limitations problem-solving imposes in lessons by establishing "the idea that complex intellectual processes should be taught through a step-by-step introduction of their component 'skills,' with each step embedding the skills of the prior steps" (Metz, 1995, p.95).

<u>The Effects of Computer Instruction on Problem-Solving Skills</u>

The theory that computer based instruction (CBI) can enhance student's cognitive performances, or problem-solving abilities, has been an area of research and concern since computers have been a part of the educational setting (Liao, 1992; Norris, et. al., 1992). Research conducted by Liao (1992) revealed that "several meta-analysis syntheses of the literature on the effectiveness of CAI (Computer Assisted Instruction) concluded that CAI is more effective than conventional instruction for increasing students' achievement. Yet, the question about the effectiveness of CAI on students' cognitive skills is left unanswered" (p.367). Liao's meta-analysis of the literature (1992) indicated only a moderate gain in students' cognitive outcomes as a result of CAI and offered the following summation as a result of the study:

> The outcomes of using CAI extend beyond the content of the specific software being used or subject being taught. Students are able to acquire some cognitive skills, such as reasoning skills, logical thinking and planning skills, and general problem-solving skills through CAI...Left

unanswered is the question of whether CAI is as efficient, or any more efficient, at developing these cognitive abilities than are other instructional approaches (p.241).

In a study conducted by Norris, et. al. (1992), the effect of computer science instruction on critical thinking and mental alertness was measured and evaluated through a computer programming course. They found that the transference of cognitive abilities to other learning domains was identified as being dependent upon the amount of time a student spent learning computer programming skills.

Another meta-analysis of 36 independent studies completed by Khalili & Shashaani (1994) "showed that computer applications have a positive effect on students' academic achievement from elementary school to college" (p.48). This study provided evidence towards the assumption that the instructional use of the computer increases student achievement, yet "very short exposure to computers is not adequate to develop students' cognitive abilities" (p.60). Also reported were the differing results of achievement in relation to the type of computer application being used in the study. Thus, some forms of computer application have a more positive effect on learning and achievement than other computer application programs (Khalili & Shashaani, 1994).

In a comparative study by researchers Cousins & Ross (1993), the effects of teaching "with" the computer to improve higher order thinking skills revealed that groups of students given task specific computer exercises significantly outperformed students in general-purpose treatment groups. This particular study also showed that student attitude towards computers effected the outcomes of scores on thinking-skills. They state that one feature in the study of the computer, as a fundamental tool to improve higher order thinking skills, is in its "graphical representation of information, which is likely to enhance and enrich the user's perspective and interpretation abilities" (p.94).

Bransford, et. al, (1990) proposed the power of images on problem-solving abilities in students compared to groups of students who were given only text-based or verbal information:

> One advantage of using (video images) is that they contain much richer sources of information than are available in the printed media...The video-based instruction resulted in much greater retelling scores and comprehension scores than did the instruction that was conducted in verbal form (pp.124-25).

This study supported the assumption that "effective problem-solving requires a great deal of specific knowledge" (p.138), and that one advantage graphic images have on students is that they condition students' knowledge and help them develop "pattern recognition abilities" (p.125). These recognition abilities set the framework for problem-solving abilities in students and allow them to employ reasoning skills to their thinking (Bransford, et. al., 1990).

The advantages and effects of CBI on problem-solving skills continues to be an area of debate and discussion (Liao, 1992; Meier, et. al. 1996). Lengel & Collins (1990) view the computer as a tool which can help students develop higher order thinking skills, but find that "few educators employ computers to help students develop collections of information into ideas...(and) computers do not often contain meaningful pictures or graphics and almost never are employed to achieve wisdom" (p.194). Today, current changes in computer technology have helped improve the graphical power and quality of computer stored images.

The Impact of Computer Technology in Science Instruction

The effectiveness of computer instruction on childrens' cognitive skills has been largely shown to improve student scores in a number of studies (Khalili & Shashaani, 1994). However, evidence of computer application in the classroom proves to be a major concern among educators (Lehman, 1994). One of the most commonly sited reasons for the deficit of computer instruction in the classroom is found in the "lack of readily available hardware/software and the lack of teacher training" (Lehman, 1994, p.413). To address this problem educators have begun to identify solutions to help bridge the gap between technology and education, and they have also started to implement programs that encourage the use of technology in their instructional lessons (Guthrie & Richardson, 1995). However, for reform in education to take place, technology needs to be integrated into a "broad effort for school reform, and considered not as the instigator of reform or a cure-all but as a set of tools to support specific kinds of instruction and intellectual inquiry" (Means & Olson, 1994, as cited in Guthrie & Richardson, 1995, p.221).

A study used to measure the use of computers in science instruction (Lehman, 1994) showed that even though the amount of instructional time utilizing computers had increased over the last five years, the frequency with which computers were used for science instruction (55%) was still low compared to mathematics (82.5%). Lehman (1994) recommended that among some of the solutions for this problem, training and experience using different computer application programs, for both preservice and credentialed teachers, should be practiced as a way for addressing the issue.

The role of computer technology in science instruction began to surface in American schools around the 1980's when a number of national reports called for reform in mathematics and science education (Lehman, 1994). Whereas most of the research on the focus of computer technology and science education were directed towards secondary education, a fewer number of studies were aimed at examining K-6 elementary use of computer technology in science instruction (Lehman, 1994). Lehman (1994) measured the use of computers and other technologies in science instruction and found discrepancies between the amount of time spent on instruction using computers between mathematics and science. He stated,

> Only about one fifth of the elementary schools had teachers who used computers...with students during science lessons. The lower frequency of computer use within science lessons reflect the assertion that the amount of class time spent on K-6 mathematics is about twice that spent on science (p.199).

Contrary to his findings, the influence of computer technology in science instruction has several foundations:

The motivational impact of computers on student achievement has proven to be an effective characteristic of their educational power in the classroom (Saettler, 1990); As a tool for improving problem-solving skills, a critical component of scientific inquiry abilities, research of computer effectiveness suggest that "humans and computers seem to indicate that problem-solving and thinking skills are learned within a particular science content" (Saettler, 1990, p.483); and, computer technology establishes the "conditions that are most effective for human learning" (Wang & Sleeman, 1994, p.61). Therefore, given its instructional power as a motivational tool, platform for developing higher order thinking skills, and integration with supported learning theories, computer-based learning programs offer a combination of benefits that promote science instruction (Gagne, et al. 1993; Saettler, 1990).

In the young child's classroom, computer technology can be seen to have a number of positive influences on learning (Jenkins, 1990). In a number of studies researching the effects of technology on young children, findings showed that technology increases cooperative learning, self-esteem, thinking and problem-solving skills, and facilitates concept development (Jenkins, 1990).

Interactive Multimedia

The term "multimedia" has qualities in its meaning that often confuse it with other technical terms such as, "hypermedia" and "intermedia" (Osborn, 1990). According to Schroeder (1992), interactive multimedia can be defined as "the integration of text, audio, graphics, still image, and moving pictures into a single, computer-controlled, multimedia product" (p.59).

Interactive multimedia projects have advantages over traditional mediums of instruction which assist the young learner's cognitive development (Jenkins, 1990). Jenkins (1990) offers examples of the instructional power multimedia brings into the classroom and states that it "can provide multiple, multisensory learning contexts...and offer a safe environment for risk taking, experimentation, exploration, and problem solving" (p.117). Multimedia also accounts for the need to address different learning styles. A discussion round-table ("Listening to Multimedia", 1994) led by multimedia experts D'Ignazio & Wagner, mentions the learning opportunities multimedia brings into the classroom and reveals the advantages it has over traditional methods of instruction. Wagner states, "Students with different learning styles must have the opportunity to learn, share, communicate, and grow using all their faculties. This is at the heart of what we mean by 'multimedia'" (p.34).

In relevance to learning theories prescribed by Gardner's theory of "multiple intelligences", in which students are believed to be suited to either one or a collection of dominant intelligences, multimedia systems have "the potential to tap and stimulate each of (the) intelligences" (Jenkins, 1990, p.116). Thus, the presence of multimedia technology in the classroom contributes to the different learning styles of children and establishes opportunities for the incitement of a variety of cognitive processes (Jenkins, 1990).

In science instruction, as well as other curriculum areas, multimedia is finding various applications and uses (Huntley, Easley & Soderhahl, 1994). The University of Iowa's center for academic computing began developing multimedia projects in 1978 called Second Look, and since then have created several programs in science which use multimedia technology (Huntley, Easley & Soderhahl, 1994). Most of these programs are designed for students studying Biochemistry, Pediatrics and Nursing.

At the middle school level in California, a multimedia based project called Science 2000 was developed to actively engage students in the study of science (Kneedler, 1993). Using the California Science Framework as a guide for planning science instruction, Science 2000 designers produced a series of four units based upon investigative questions. The final product was an immediately accessible special resource entailing "simulations, investigations, hands-on experiments and manipulatives, films and videos, field trips and guest speakers, information on scientific careers and available databases, glossaries of related terms, and performance-based assessments that are open-ended" (Kneedler, 1993, p.73).

The effects of multimedia on instruction and student achievement disclose a mixture of positive results (Wise & Groom, 1996). Results from a study measuring the effects of multimedia employment on classroom learning (Wise & Groom, 1996), concluded that multimedia had several impacts in the classroom among which include:

> ...elevated student and faculty interest, the holding of student attention, student individual and group participation, in-depth understanding, the ability to associate knowledge to other subjects and areas, the ability to generalize, the stimulation of interest in related or parallel topics, the desire to continue learning as an enjoyable experience, the ability to explore methods of self learning, and the ability to use multiple display techniques to make otherwise dull subjects come alive and allow for more creative means of expression (Wise & Groom, 1996, p.70).

The power of multimedia in the classroom presents a variety of instructional benefits that enhance learning among students. Given its instructional power, educators can give it license and unleash creativity and thinking among students. Ambron (1990) emphasizes this point and states, "The ability to communicate with multimedia will give a new dimension to information and will change how we think about problems" (Ambron, 1990, p.71). Multimedia also activates student learning by appealing to a student's different senses through the exploitation of different mediums. Caitlin, et. al. (1996) measured the effect of multimedia on a group of visually impaired students and discovered that "memory is best engaged if a student employs a variety of senses to comprehend, examine and reflect the information in the process of storing it" (p.90). However, perhaps the greatest influence on learning multimedia affords is through its uniqueness and openness for being able to produce customized programs which motivate and stimulate learning.

Creating Personal Programs Using Authoring Systems and Screen Design Principles

Dahmer (1994) defines an authoring system as being like the sets of tools a carpenter would use to build a house. These tools are analogous to the electronic tools needed to make multimedia programs, such as those used to edit text or make graphics and animations. Most of the packages available to the programmer can be found in two modes: one for the inexperienced programmer; and the other in the form of a scripting language (Dahmer, 1994).

Today, anyone with a computer and limited experience can create their own CBI program using authoring packages available on the market. Overbaugh (1994) explains that the recent development of newer authoring systems provide tools for nonprogrammers to create software, yet "developers should draw on the experience of instructional design theorists and researchers involved in the development and evaluation of educational courseware" (p.29).

Several theories abound dealing with how personal authoring systems should be used in the structuring of CBI programs (Overbaugh, 1994; Ross & Moeller, 1996). Overbaugh (1994) prescribes a "process by which a predetermined instructional need will lead to pedagogically sound computer-based courseware" (p.29). The stages include:

* lesson design: defining the instructional set and teaching strategies;
* student performance: eliciting and assessing performance;
* and feedback (Overbaugh, 1994).

Using Gagne's model of instructional events as a framework for designing CBI programs when working with an authoring system, Overbaugh (1994) breaks down each instructional event into three learning domains: instructional set, teaching strategies and student performance.

Instructional Set

The instructional set encompasses Gagne's first three events of learning: gaining attention; informing learners of the objectives; and stimulating recall of prior learning (Overbaugh, 1994). The purpose of the instructional set "prepares learners to engage in the forthcoming new information" (p.30). Bransford et. al. (1990) shared a commonality with Overbaugh's view and presented their theory of "anchored instruction" in which "an emphasis on the importance of creating an anchor or focus that generates interest and enables students to identify and define problems and to pay attention to their own perception and comprehension of these problems" (p.123).

Overbaugh (1994) wrote that the instructional set can be enhanced using several CBI design theories, and that the process of gaining attention can be sufficiently established in a variety of ways using CBI; such as through a title screen, a visual stimuli or situational description. Wang (1994) reviewed literature which showed that the most effective CBI programs were those that varied the use of features such as color, print size, text display rate, and others as a function for gaining attention. More importantly, gaining attention also serves a purpose for motivating students towards instruction and orienting their cognitive abilities at the early stages of the program.

Teaching Strategies

The teaching strategies domain is comprised of three events: presenting stimuli, providing learner guidance and enhancing student retention and transfer. This stage of the course activates students' cognitive abilities and aids them in the process of their thinking (Overbaugh, 1994). Presenting stimuli using the computer entails important factors which must be considered when presenting information on the computer screen (Overbaugh, 1994; Ross & Moeller, 1996). Overbaugh (1994) recommends to "keep the screen as simple and uncluttered as possible because presenting too much information at one time can be confusing and overwhelming" (p.32). However, a study examining whether screen design incorporating graphics and text effects students' learning indicated that "the placement of text and/or visuals may not positively influence student achievement on different educational objectives" (Noonen & Dwyer, 1994, p.325).

The purpose of color in a CBI program can have both positive and negative effects on learning (Overbaugh, 1994). The effects of color in computer screen designs and learning is shown to be most effective when consistently used for highlighting and drawing student attention to details; however, its effects can be distracting and hinder high achievers when overused (Overbaugh, 1994). Ross and Moeller (1996) evaluate the use of color and warn that "spectrally extreme colors," like red and blue, can cause eye fatigue and headaches.

Providing learner guidance can follow the precepts of two different strategies for presenting information: elaboration and inquiry learning (Overbaugh, 1994). The thought of providing guidance using elaborations helps the learner receive information in its basic form and then move "progressively toward the more complex aspects" (p.32).

Jehng & Spiro (1990) cite two factors which relate to the progression of knowledge from the concrete to the abstract:

> Two important things happen as you move beyond the initial introduction to a content area to more advanced stages of knowledge acquisition in that area: First, the conceptual concepts tend to become more complex and the basis of its application more ill-structured; and second, the goals of learning and criteria by which learning is assessed shift...from (a) introductory level familiarity with concepts to the mastery of important aspects of complexity (p.167).

Overbaugh (1994) suggests combining the strategies of "inquiry learning" and "elaborations" for effective learning guidance. Both are processes which involve methods of instruction that are centered on inquiries, and guide the learner to a response that is reflective of learning objectives.

The final objective in providing learner guidance is enhancing student retention and learning transfer. Overbaugh (1994) recommends a series of strategies to aid student retention. One of these strategies is the use of "synthesizers." Synthesizers are recognized as the tools that help increase student retention by helping them to "compare and contrast related ideas and show how ideas fit within the overall knowledge structure to increase meaningfulness and motivation" (Overbaugh, 1994, p.34). Gagne, et. al. (1992) suggest that synthesizers, and other learning tasks presented by the instructor, can be accomplished in a "variety of novel 'application' situations for the purpose of ensuring the transfer of learning"(p.198). Thus, the theory behind learning transfer and CBI presents that "when the learner applies new learning to new contexts, he acquires additional cues that later can be used in searching long-term memory for the appropriate capability" (Wang & Sleeman, 1994, p.70) to solve problems. These "cues" are the executive cognitive processes which allow the student to retrieve previously learned material from their long term memory and represent "the core phase of learning" (Wang & Sleeman, 1994, p.64).

Student Performance

Overbaugh's (1994) third domain of learning is referred to as "Student Performance." In this domain are a subset of instructional events which include eliciting performance, assessing performance and providing feedback (Overbaugh, 1994).

Eliciting performance requires a learner to demonstrate that a newly learned behavior has been learned (Gagne, et. al., 1992). Research cited by Wang & Sleeman (1994) indicated that "students learn more when they are able to handle tasks and questions with high rates of success, and that high-success activities are often associated with higher levels of student on-task behavior" (p.68). Consequently, active students will likely spend more time on task, view embedded information and score higher on achievement tests (Ross & Moeller, 1996). Overbaugh (1994) adds that, "performance demands should be within the learners' reach in order to enhance achievement-striving behavior; therefore, designers may accept lower standards at early stages in the learning process" (p.34).

Following student activity is the process of assessing performance which "establishes whether or not the new learning has reasonable stability" (Wang & Sleeman, 1994, p.69). Gagne, et. al. (1992) warn that some performances may not be reliable and therefore require additional opportunities for providing evidence that a "learned capability" is genuine. Assessment may also be directive and provide guidance for correct or incorrect answers (Gagne, et. al. 1992). In essence, the computer can provide the best situation for assessing performances, and as Overbaugh (1994) attests: "it patiently waits for students to absorb information and formulate responses; it provides all learners with the same level, quantity, and quality of assessment procedures; and it simulates situations that resemble or closely represent 'real' situations" (p.34).

Another critical component in the design of CBI programs is the provision and standard of feedback for learner performances (Gagne, et. al., 1992). "Providing students with information about their own learning facilitates performance" (Overbaugh, 1994, p.35). The theory behind feedback is that it will inform the student the degree for which his/her answer is correct, and the student will consequently make corrective action or continue with the program of instruction (Wang & Sleeman, 1994). Research on feedback indicates that student achievement is higher when learners are provided with prompt responses regarding the correctness of their thinking (Wang & Sleeman, 1994). Furthermore, feedback is shown to prevent "lost-learner" problems and restore achievement (Ross & Moeller, 1996). Overbaugh (1994) states that CBI programs "can be designed to provide adaptable feedback based on learner responses and to recognize responses that are not entirely correct" (p.36)

Conclusion

Science instruction has evolved over time with the impacts of various influences encompassing societal changes, technological advances and the understanding of how learners process information. Early reformists called upon changes towards instruction and theorized that discovery based learning, appropriately designed to meet the maturity of the learner, was more influential than rote or passive learning strategies of the past. Science instruction continued to be a central issue of debate and concern for many years. As society and its perception of science changed, so did the curriculum. Today, science instruction is moving away from the linear approaches of textbook adoptions and is focusing upon the process of how we teach students, rather than what we teach.

In the 1960's cognitive researchers began to help reshape people's perceptions of learning. Learning theories presented by Piaget, Ausubel and Gagne concluded that new knowledge is achieved through specifically learned rules. With the advent of technology, Gagne established a hierarchy of instructional events which could contribute to the method of presenting instruction and effect learning outcomes. Contrasted to the discovery based learning approach, Gagne's theory was perceived by some educational theorists as being a structured model for presenting information.

Issues in science today, as prescribed by the California Science Framework (1990), call for more active learning on the part of the student. Direct experiences, using hands-on materials and investigations, are a necessary focus in science instruction. Science curriculum developers are producing an array of science study kits, using themes and topics to direct content objectives and lesson designs. Consequently, educators question the instructional significance of hands-on materials, especially for young students. Some of the concerns center on the relevancy of hands-on materials and the misconceptions children could develop when working with them. Even more, because of the conceptual skills of young learners, it is maintained that hands-on materials misguide children's understanding of lesson objectives and stifle their ability to make effective interpretations. Thus, educators look for meaningful methods to utilizing hands-on materials in a structured environment. Instructional materials must do more than stimulate students' interest in concepts, but must also aid their attention onto investigative abilities and the application of critical thinking skills which go beyond observing, ordering and classifying.

Connections between learning using hands-on materials and problem-solving skills are seen as viable methods for addressing young students' understanding of science. For many years educators have striven to promote students problem-solving skills. As the twenty-first century approaches, a number of visionaries are seeing a demand for students with sensible problem-solving skills and ability to work in a demanding and changing workplace. Because of the evidence which suggests that many of the students entering the workplace today are inadequately prepared, educators are looking into ways for implementing problem-solving skills in their lessons. The research indicates that the teaching of problem-solving skills should begin at an early age. Lessons should be designed to effectively engage student understanding at a level matched to their intellectual needs, and build upon skills already mastered. Limitations in the design of problem-solving lessons effect learning performances, but can be rectified using Gagne's model of learning which builds upon a student's component skills.

Computer based instruction (CBI) is viewed as one method for effectively enhancing student problem-solving abilities. CBI is proficient in increasing student achievement when compared to conventional methods of instruction. It can have a positive effect on learning by utilizing an adept visual medium rather than text-based or verbal formats of instruction. In relation to addressing student problem-solving skills, CBI presents information in a manner that can be programmed based upon the component and entry skills of the learner. The impact of CBI in science instruction is found to increase student achievement, interest, motivation and attitude towards science. Regarding problem-solving skills, it can provide a platform for delivering instruction that is integrated with learning theories such as Gagne.

As a learning tool, CBI can be enhanced using multimedia. The power of CBI programs using multimedia actively involve students through the use of visuals, sound and text. Multimedia can appeal to the different learning styles of young learners through its unique presentation of information in a variety of formats. It has several benefits in the classroom including greater student motivation, attention and creativity.

Authoring systems can positively change CBI programs. Following Gagne's model of instructional events, authoring systems can allow a programmer to create courseware, and employ concepts defined by learning theories into meaningful instructional programs. Screen design principles add components to programs which effectuate learning, and the flow of information can be set up to address the learning objectives using an authoring system. Authoring systems can also establish programs that are designed to increase student performance through instructional sets which activate previously learned material, and guide learner responses through questioning and meaningful feedback.

CHAPTER III: GOALS AND OBJECTIVES

Project Goals

The primary goal of this project will be to develop a computer based instructional program to complement the contents of the Desert Habitat Study Kit. The project will be based upon computer screen design and learning principles, and utilize the hands-on materials of the study kit as the basis for its design.

The project will follow specific information presented by the study kit and reorganize this information to help the students achieve learning objectives which promote problem solving-skills.

Project Objectives

Using the theme "plant and animal adaptations" students will make observations using the hands-on materials, and information presented to them through the project, to successfully demonstrate an understanding of how animals and insects adapt to the desert. Learners will also answer to concepts such as: identifying particular desert animals and insects, identifying where an animal lives, and defining what adaptations an animal makes to survive in the desert. Upon mastery of these objectives, students will simulate their own desert animal for successful adaptation in a desert environment.

Project design objectives will follow the "hierarchical learning" approaches for establishing problem-solving skills (Gagne', et. al., 1992); in which students will be taught through a step-by-step introduction of component skills, with each step embedding the skills of prior learning. Component skills for instructional objectives are based upon the following desert animal adaptations for survival: Physical Characteristics, Diet, Habitat and Defense.

CHAPTER IV: PROJECT DESIGN AND DEVELOPMENT

Background

The San Bernardino County Museum’s Educational Outreach Program was created as a means for establishing collaborations with schools throughout San Bernardino County. Using a direct-learning and hands-on approach, program coordinators developed a series of habitat study kits reflective of the different environmental regions of the county. The purpose of the museum's study kits is to help teachers enrich their science instruction by including collections of hands-on materials which facilitate learning experiences for students.

One of the kits offered to teachers through the museum’s loan program is the Desert Habitat Study Kit. The Desert Habitat Study Kit contains sets of preserved plants and animal specimens which the students can see and hold. Each of the animal specimens are categorized by species, such as mammal, bird, reptile and invertebrate. The Desert Habitat Study Kit also contains background information on each of the plants and animals, a filmstrip, six reproducible worksheets and a copy of activity ideas. The learning objective of this kit is to present learners with different plant and animal specimens of our desert regions, and help them identify each one based upon their distinctive traits and abilities.

Project Structure and Content

The *Animal Adaptations in the Desert* software project was completed as an instructional supplement to the County Museum's Desert Habitat Study Kit. The intention of the project was to create a computer based instructional program which will help students in the third grade understand the content of the Desert Habitat Study Kit, and acknowledge the adaptive abilities of the Desert Habitat Study Kit's animals and insects through a series of problem-solving activities. The project makes ample use of animations, sound, video and text to help fulfill this objective.

The primary goal of the project is to orientate student learning through events of instruction which help them understand how animals adapt. Concluding activities in the project follow a hierarchical format; initiating basic identifying and recall skills from the user, and then lead up to problem-solving skills. This project is also based upon The California Science Framework's (1990) theme for life science in grades three through six, entitled "Systems and Interactions." To assist students in understanding the delicate relationship animals of the desert have with their habitat, the theme of animal adaptations is reviewed throughout the project for each animal and insect.

The title screen of this project (see Figure 1) greets the student with a computer-drawn background of a desert landscape, the title of the project, and three windows showing motion video clips of plants and animals found in the desert. The motion video clips automatically play when the project is activated, but can also be replayed by clicking on any of the windows. The title screen catches the student's eyes, and contains graphic images which serve to orientate the student's thinking about the desert and the animals that live there. To access the main menu, students must press the arrow button which is directed towards the right.

The stacks in this project cover specific information pertaining to the different animals and insects of the Desert Habitat Study Kit, and can be selected by the user from the main menu screen. Figure 2 illustrates the main menu screen of Animal Adaptations in the Desert and offers five areas for student exploration and interaction: mammals, reptiles, birds, insects and activities. The student may also opt to quit the project from this screen or get help. From this point in the project the stacks are broken down by individual animals and activities, and represent the overall content of *The Animal Adaptations in the Desert* project.

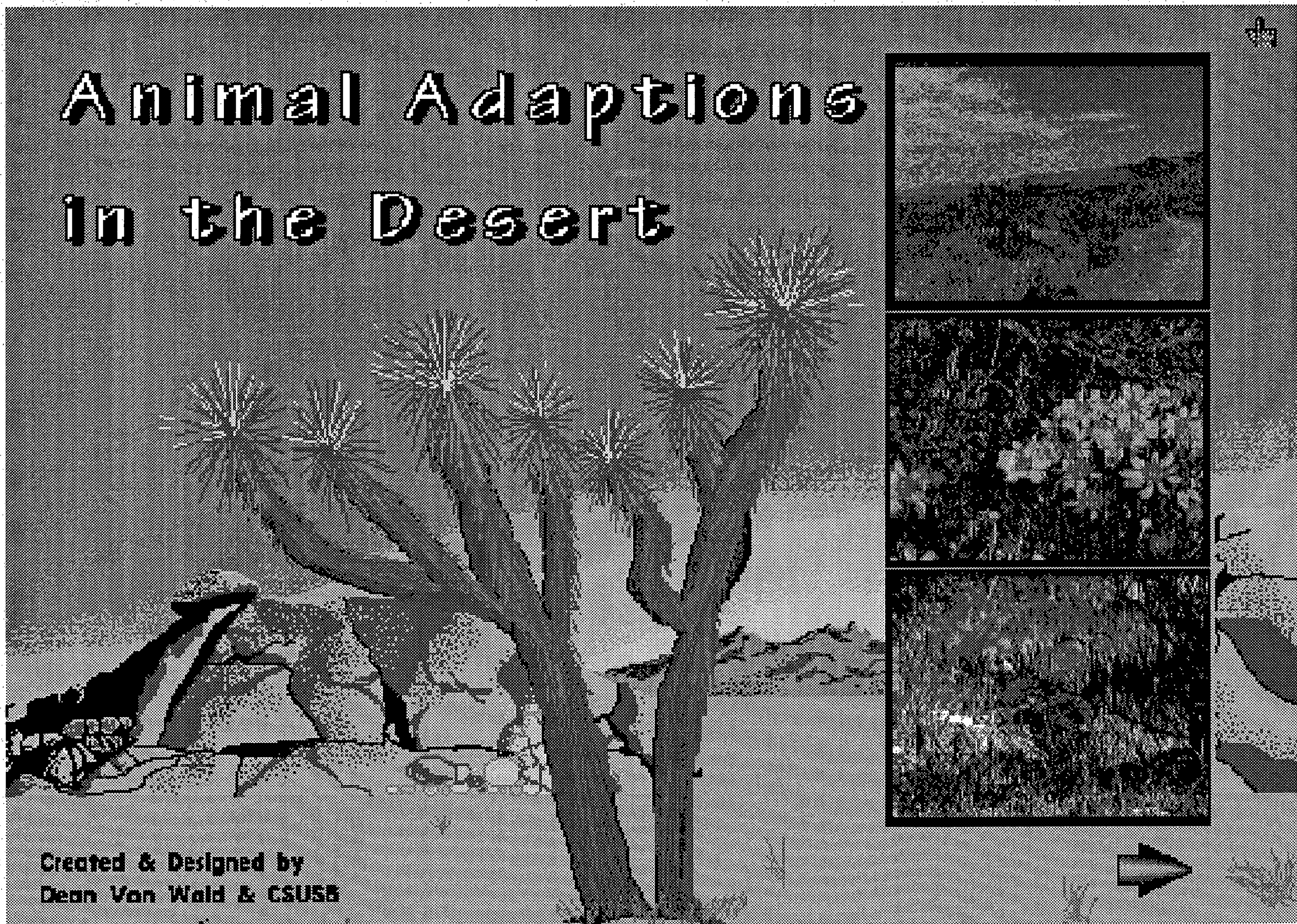


Figure 1. Title Screen

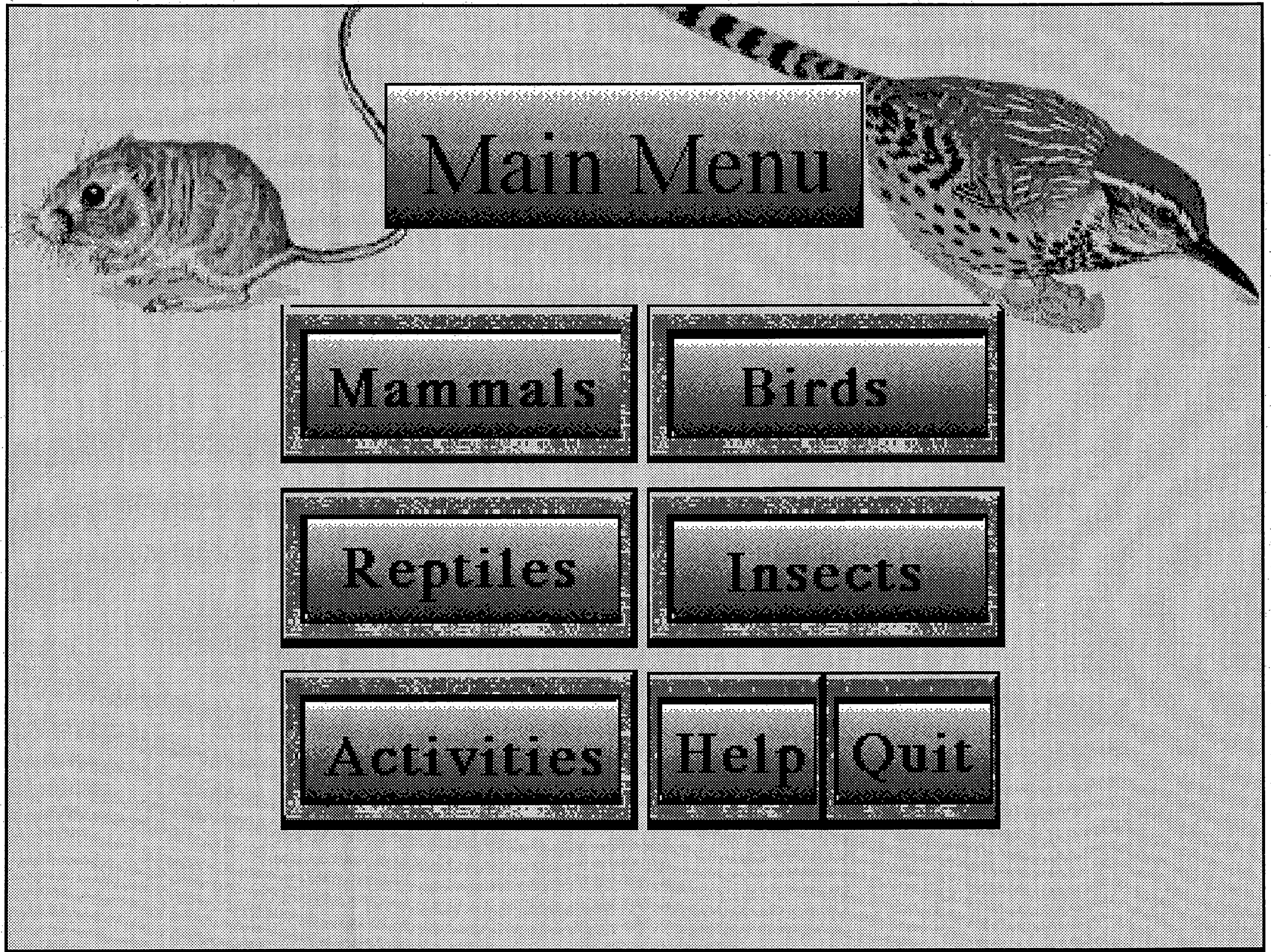


Figure 2. Main Menu

The organizational structure of the project is illustrated in Figure 3 and shows how information concerning the "Fringe-toed Lizard" and "Build an Animal Activity" are laid out. All of the stacks are linked together and allow students to navigate with ease from one topic area to another

The content of this project is comprised of animals which can be found in the study kit and are as follows:

* Three mammals: The Wood Rat, Kangaroo Rat and The Whitetail Antelope Squirrel;
* Two birds: The Cactus Wren and The Horned Lark;
* Three reptiles: The Desert Tortoise, The Fringe-toed Lizard and The Sidewinder; and
* Three insects: The Scorpion, The Thread-waisted Digger Wasp and The White-lined Sphinx.

Once the student selects the animal of his choice, he can begin navigating through the stacks and choose areas he is interested in learning about. Depending on the animal the student selects, details about that animal are broken into four topic areas and can be accessed through specific submenus: Information, Diet, Habitat and Adaptations (see Figure 4). Figures 5 and 6 reveal how concepts pertaining to birds and insects in the project are respectively disclosed, and do not contain the same sets of detailed information as the mammals and reptiles do because of their physical traits.

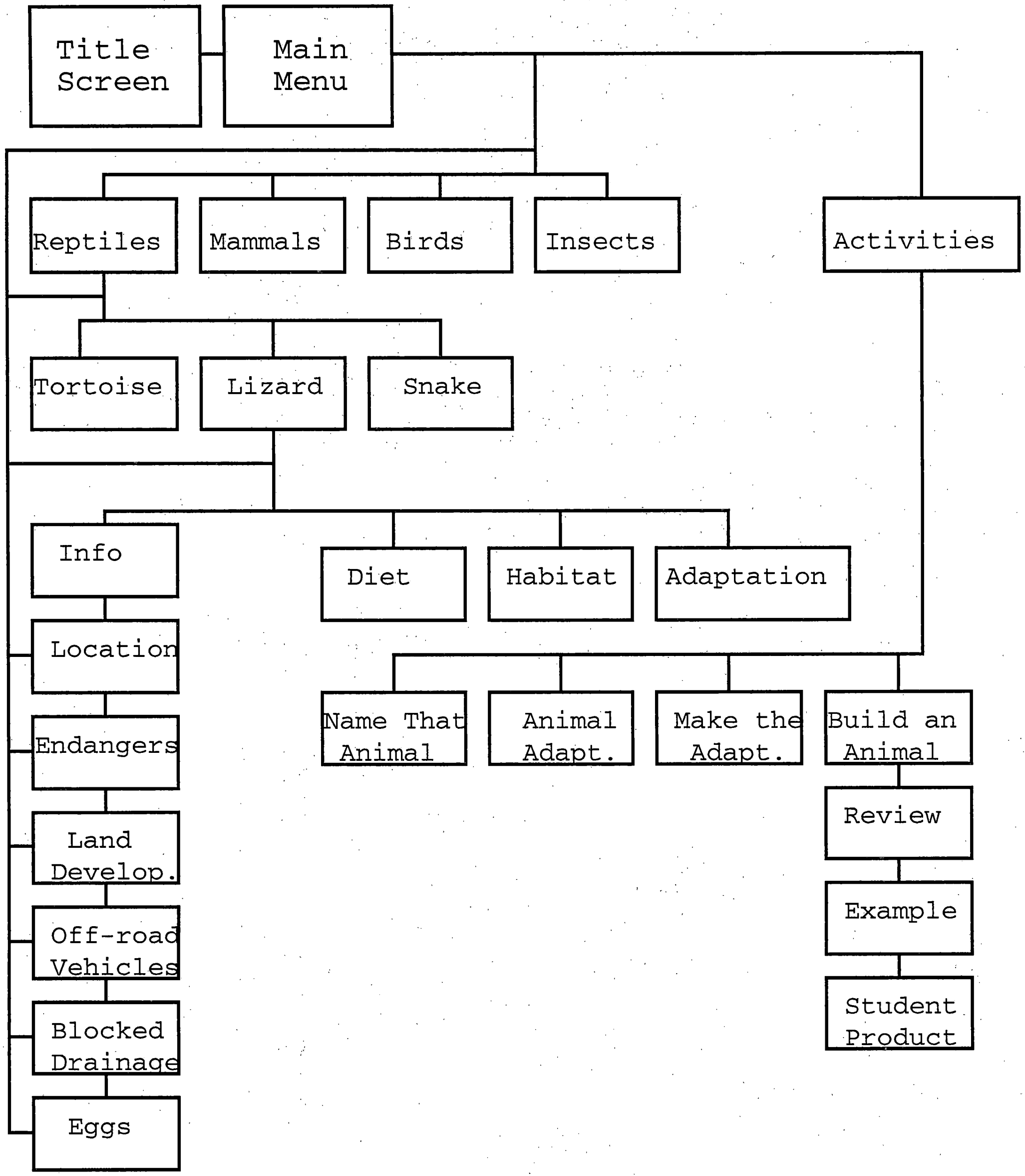


Figure 3. Organizational Structure of "Fringe-toed Lizard Information" Stack and "Build an Animal Activity" Stack.

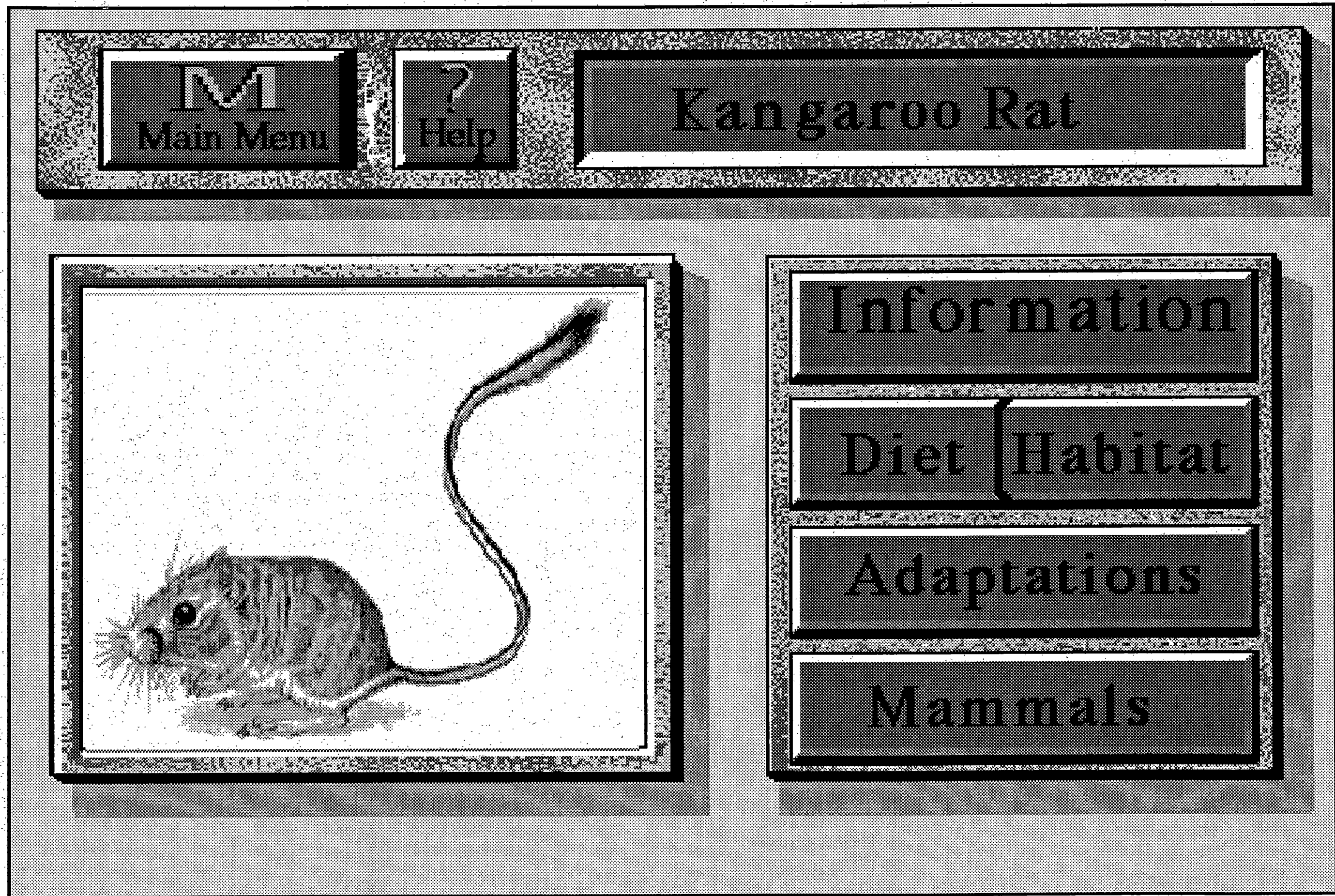
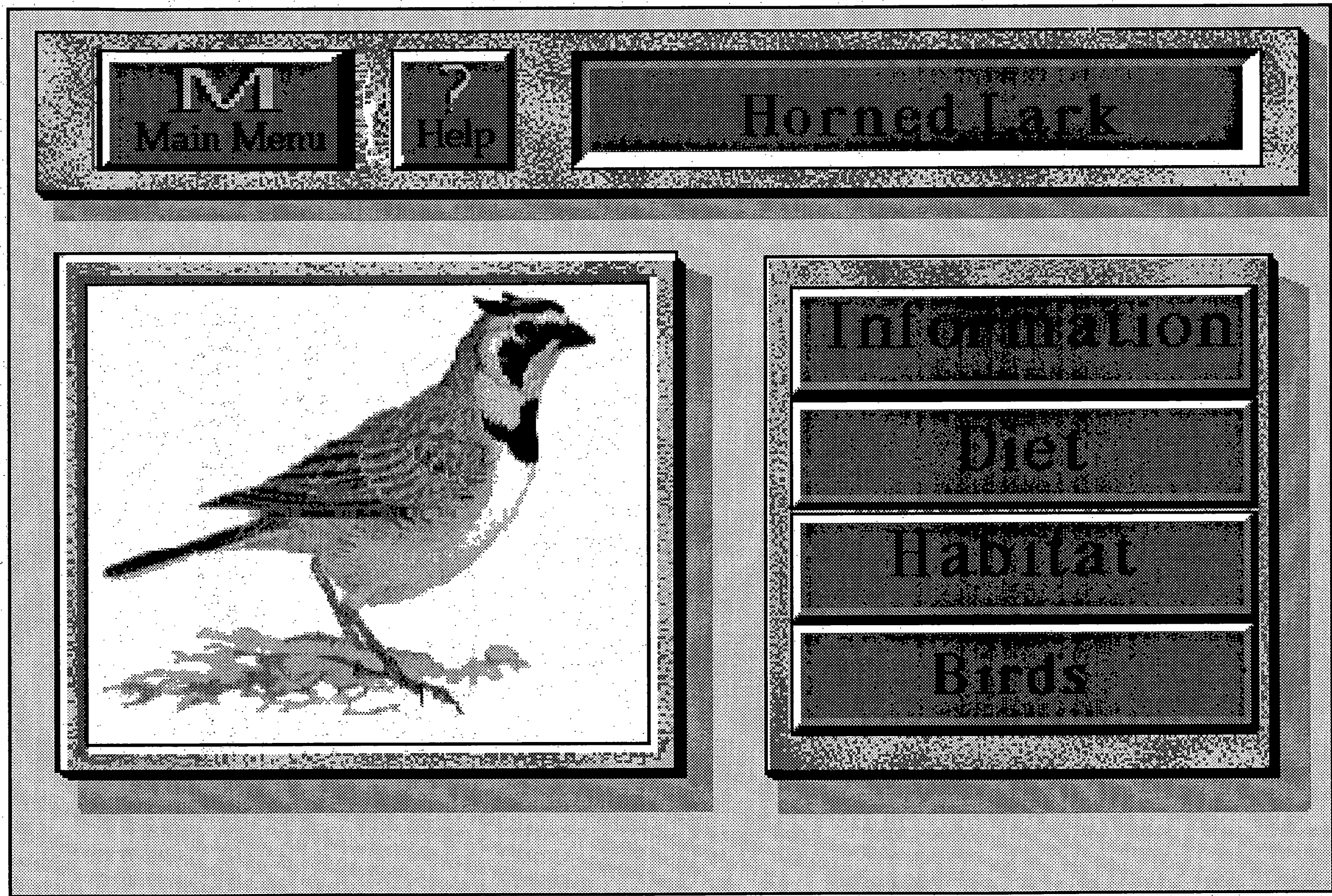
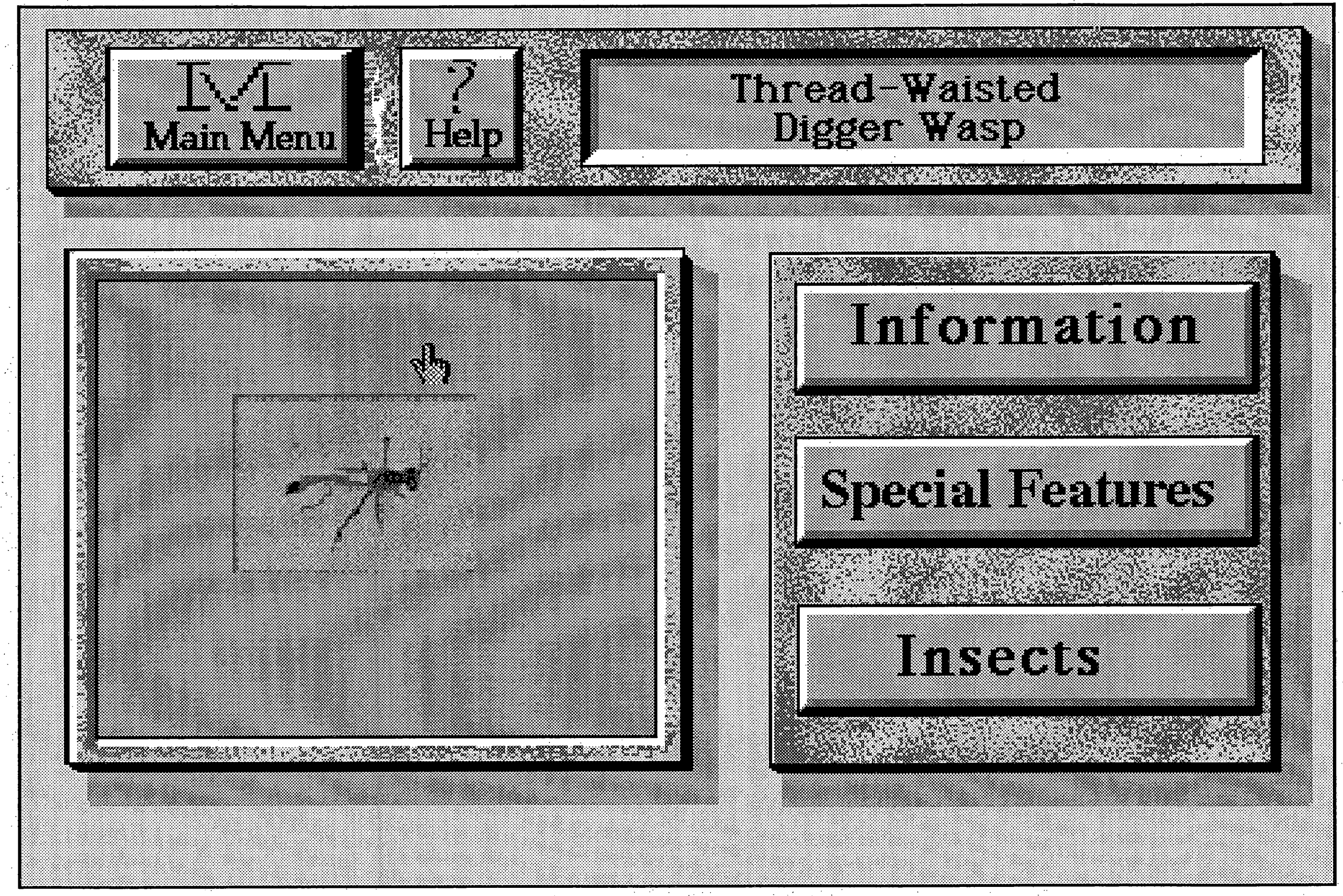


Figure 4. Sub Menu



<u>Figure 5</u>. Sub Menu for "Horned Lark"



<u>Figure 6</u>.   Sub-Menu for "Thread-Waisted Digger Wasp"

"Information" stacks report facts about the background of each animal and consist of either motion video clips, digitized pictures or animated graphics. The text in the "Information" stacks briefly explain basic features of each of the animals and insects. The "Diet" stacks report information about the diet of each mammal and reptile in the project, whereas the "Habitat" stacks show the different areas and niches these animals survive in. The "Adaptation" stacks provide information to the student on how each animal successfully suits itself to its environment; even more, these stacks relate facts such as: estivation, migration or animal metabolism.

Once the student has completed the stacks for each of the animals and insects they may begin to navigate and complete the activities presented by the project. In all, there are four activities in the *Animal Adaptations in the Desert* project. They are as follows:

* Name That Animal: A basic recall activity which requires that the student identify a particular animal or insect based upon certain characteristics described to them;
* How Animals Adapt: This activity lets students define how particular animals adapt to their habitat.
* Make The Adaptation: Given a specific habitat, the student chooses the correct adaptive features that would help an animal survive.

* Build An Animal: The student can create their own desert animal and describe how it survives in its habitat.

Technology Requirements

This project requires the use of a Macintosh Computer, preferably from the Power Macintosh platform, and the programming software Hyperstudio 3.0 for maximum operation. Appropriate RAM demands are in the range of 50 to 60 megabytes (MB). The project is currently stored on a "Zip Drive" disk which stores up to 100 MB (See Appendix B). Because of the amount of video segments and animations, Higher performance, faster computer response time and better resolution of graphics will result if the user has access to a "Zip Drive" device to operate the program.

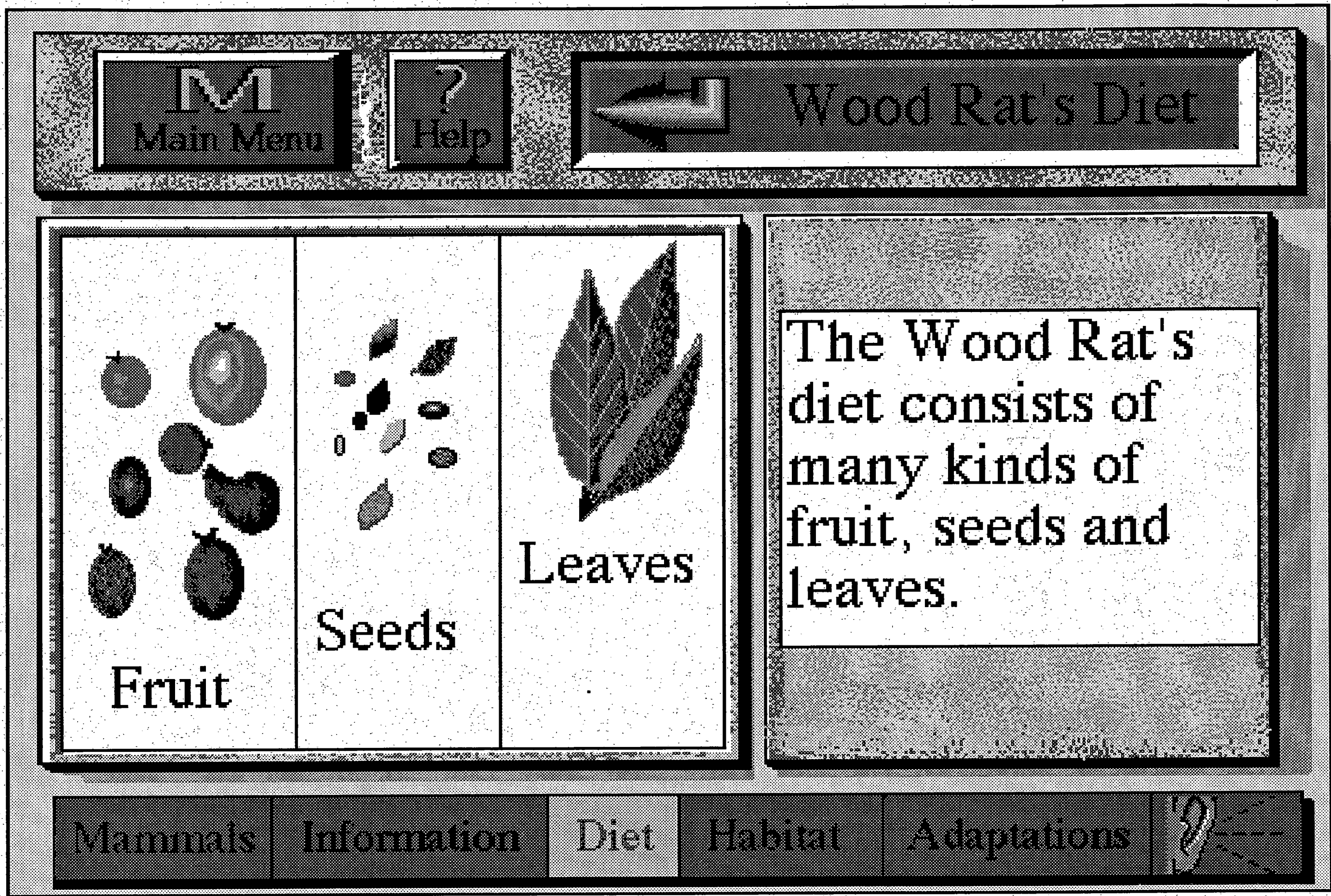
Navigational Design

The *Animal Adaptations in the Desert* project is a comprehensive computer based instructional program detailing facts and information on a number of different animals and insects. The inclusion of a functional navigational system for this project was designed to assist students in working with the different stacks. A stack with only one card was designed with a return arrow which routes the student back to the submenu (see Figure 7).

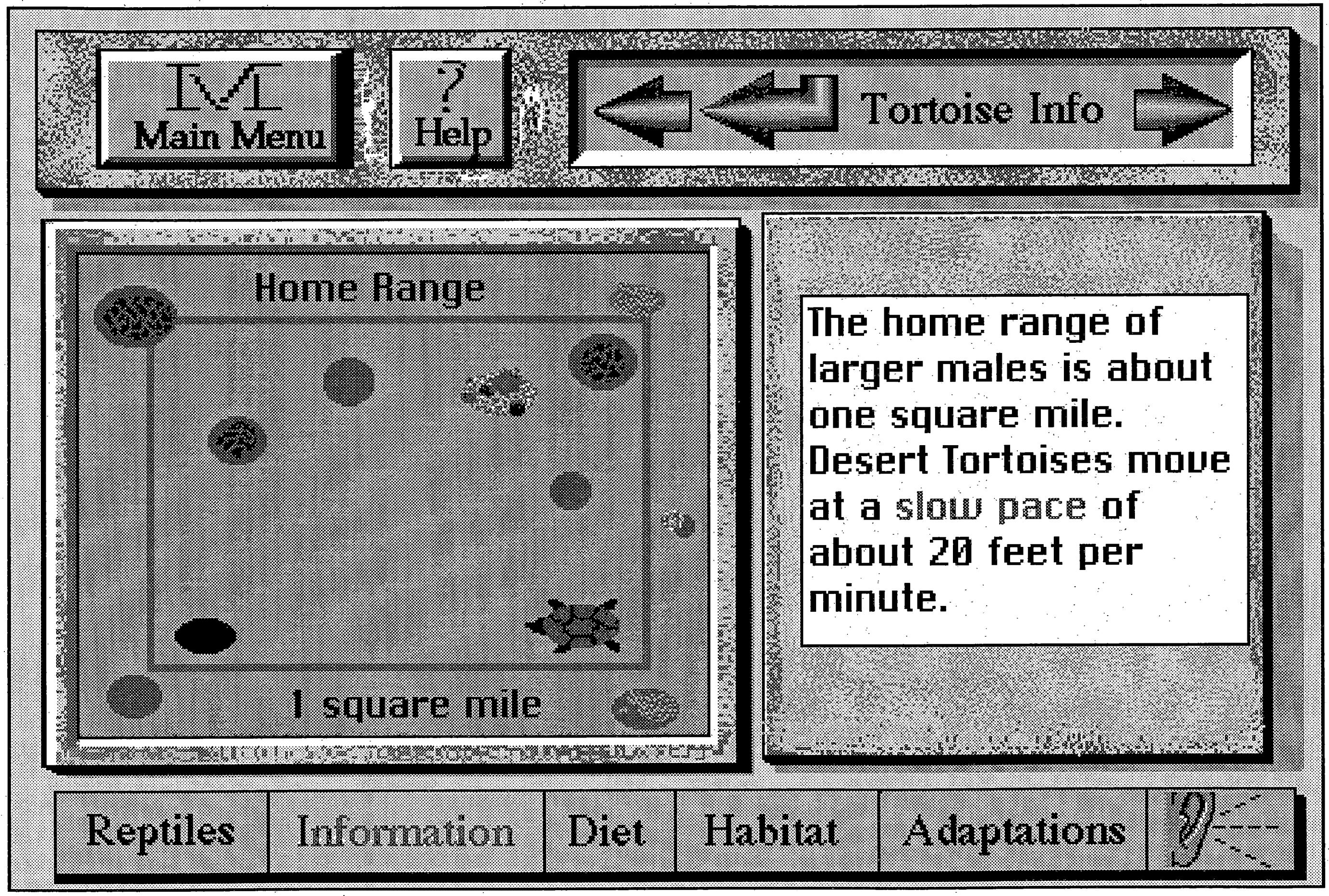
Conversely, Figure 8 shows how a stack with multiple cards would appear in this project. The left arrow takes the student to the previous card, whereas the right arrow takes the student to the next card. Clicking on the return arrow will reopen the submenu stack.

Arrows are arranged on the top of each card where they can be easily found and are placed similarly in all of the stacks. The student may also click on the section of buttons on the bottom of the screen to navigate within a specific animal's stack. These buttons offer an easier method for moving from one topic area to another, ie. information, diet or habitat. Depending on where the student is located in the stack, one of the buttons are shaded with a different color to help him or her know where they are in the program. In certain stacks an icon of a magnifying glass is used to navigate the program. Students may click on the icon to see different perspectives of an animal (see Figure 9).

The concept of learning principles was applied in the design of the navigational system as well. The navigational system provides a framework for learner guidance and stimulates the direction of student thought. Figures 9 and 10 depict how the navigational system is used to guide students and elicit a response from them.



<u>Figure 7</u>. "Wood Rat's Diet" Card



<u>Figure 8</u>. "Desert Tortoise Information" Card

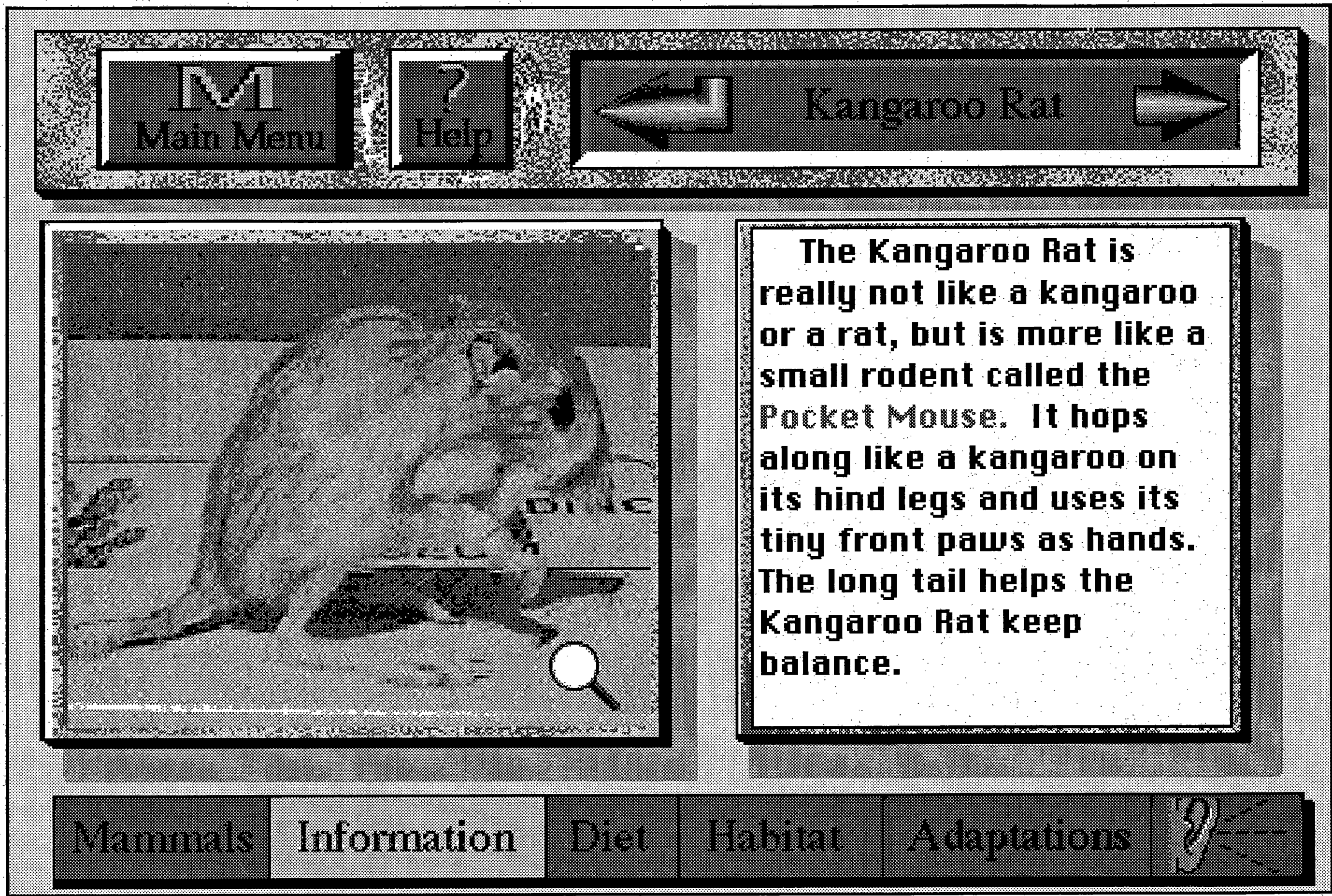


Figure 9. "Kangaroo Rat Information" Card

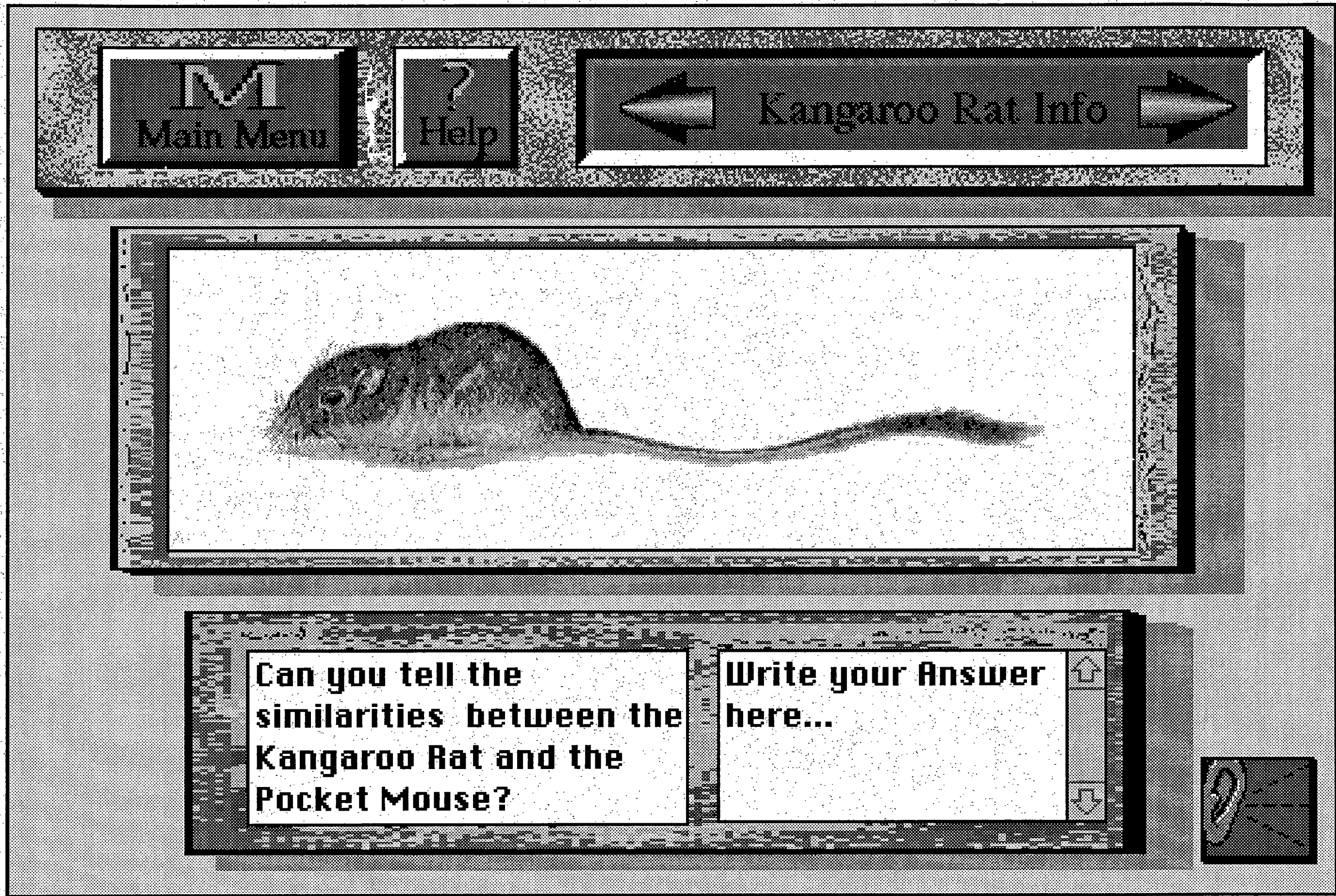


Figure 10. "Pocket Mouse Information" Card

In this example, a highlighted word in the text screen acts as a button to move the student to another level of learning, ie. distinguishing the similarities between a Kangaroo Rat and a Pocket Mouse. The left arrow on the next card (see Figure 10) provides the student with a link to previously learned information.

Thus, the student may feel free to move back to the previous card before making a response to the question. The right arrow on this card guides the student to the correct answer.

The navigational design of this project can be manipulated by the student so that information is presented in a nonlinear manner. Once the student begins to understand the functionality and purpose of the navigational design, they can independently move from one topic area to another and chose specific areas of interest without having to go through a whole set of cards. Figure 11 portrays how an individual may navigate from one topic area to another. Using a nonlinear approach for navigating the project, a student may routinely return to the main menu from any card in the project, or access topic areas within a stack's sub-menu.

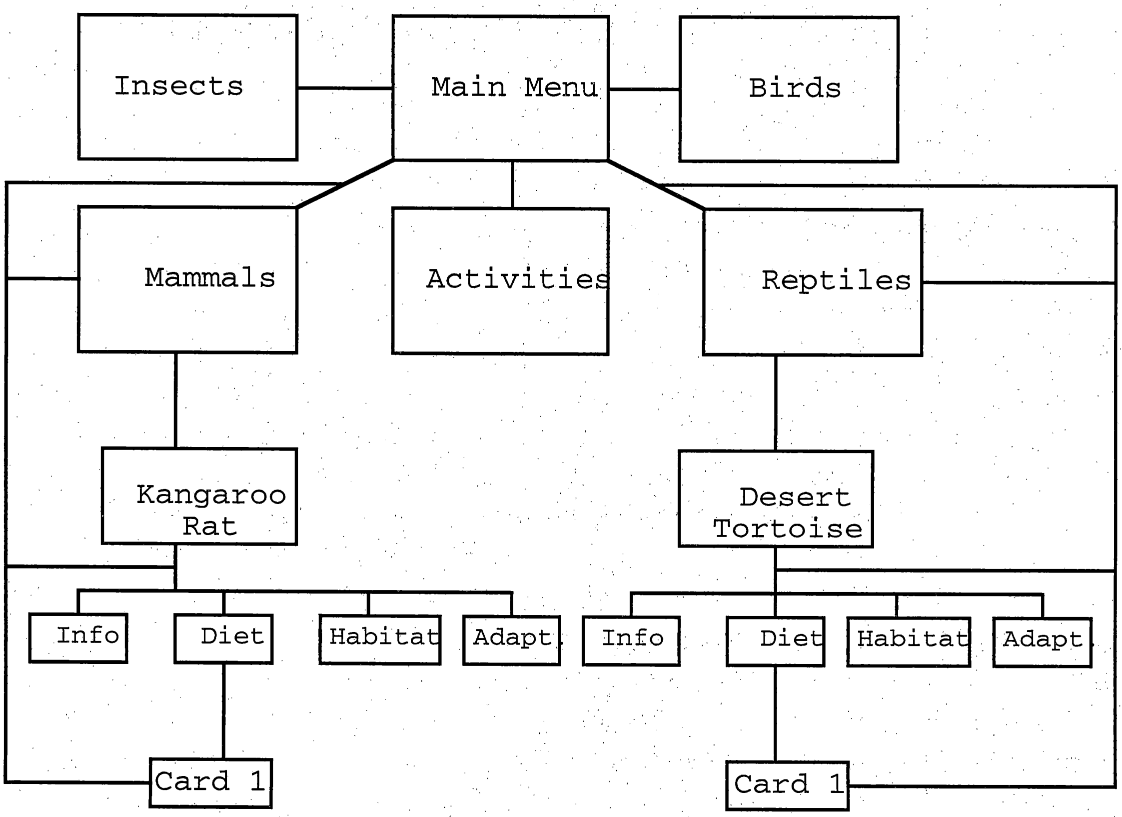


Figure 11. *Animal Adaptations in the Desert* - Navigational Flow Chart for "Kangaroo Rat Diet" Stack to "Desert Tortoise Diet" Stack

Instructional Design

The *Animal Adaptations in the Desert* project is based upon Robert Gagne's "Events of Instruction" (1992), and the computer programming principles of Richard Overbaugh (1994; see chapter 2). Because of the extensive size of the project's content, the matter of illustrating its instructional design will be described using stacks from the "Kangaroo Rat" and some of the follow-up activities.

Beginning with the concept of focusing the learner, the initial process of gaining the student's attention is achieved through the use of digitized camera images of the animals and insects from the study kit (see Figure 12). These visuals provide a stimulus which motivate student interest in the program and help them to begin formulating perceptions about the content area. Title screens work to orientate student thinking and communicate the objectives of the stack's content. For instance, Figure 13 shows how the objective of informing the student of the Kangaroo Rat's diet is completed through the use of a title screen, graphic image and supporting text field. Multimedia techniques, such as sound, video and text, also help to combine the newly learned material with concepts learned from the study kit. Thus, when a student actually sees or hears about the Kangaroo Rat's diet, they can relate this fact to the animal which they learned about previously from the study kit.

<u>Figure 12</u>. "Kangaroo Rat Information" Graphic

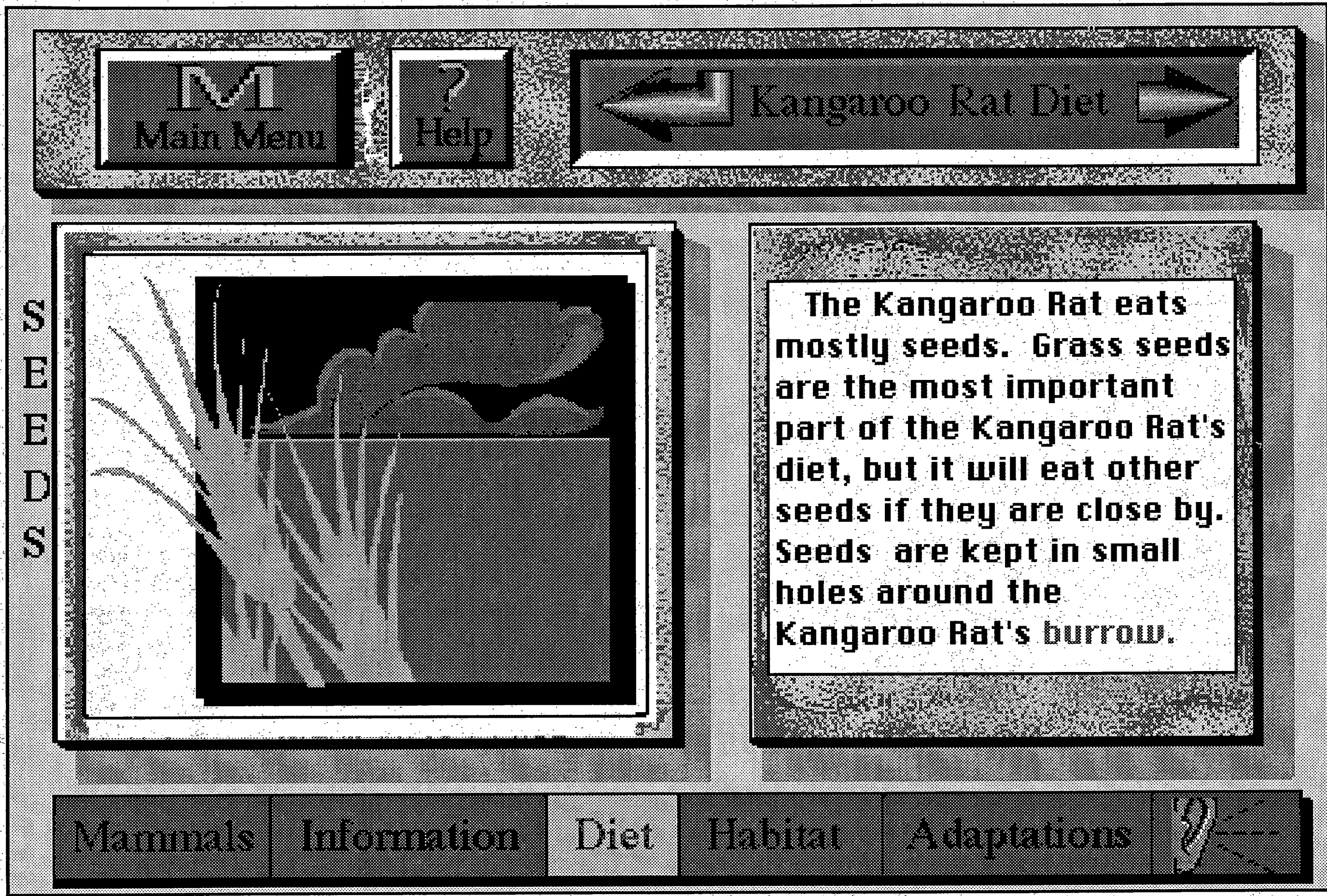


Figure 13. "Kangaroo Rat Diet" Card

Text and highlighted words serve the purpose of presenting material to the student, and provide critical examples of the content's objectives (see Figure 14). The highlighted text reinforces new skills using animations, and presents the material with a combination of moving pictures and sound.

The student is provided guidance through several different programmed features that are reflective of the learning objectives. This particular learning principle can be seen in the activity "Name That Animal", which requires students to identify particular animals from the project (see Figure 15). The "clue" button on the menu bar provide cues which help the student retrieve previously learned material, and then allow the student to return back to the original inquiry (see Figure 16). Sound buttons relate important material to the user and are designed to help them make sense of the information displayed on each card. Cards in stacks are also structured in a linear format, and present material through a progression of linked concepts.

The activity section of the project is comprised of stacks which draw responses from the student. Furthermore, both positive and negative feedback to student responses is programmed throughout all of the activities. If a student makes an incorrect response, they hear a particular sound which they soon learn suggests that their answer was not right. However, if they make a correct answer to the

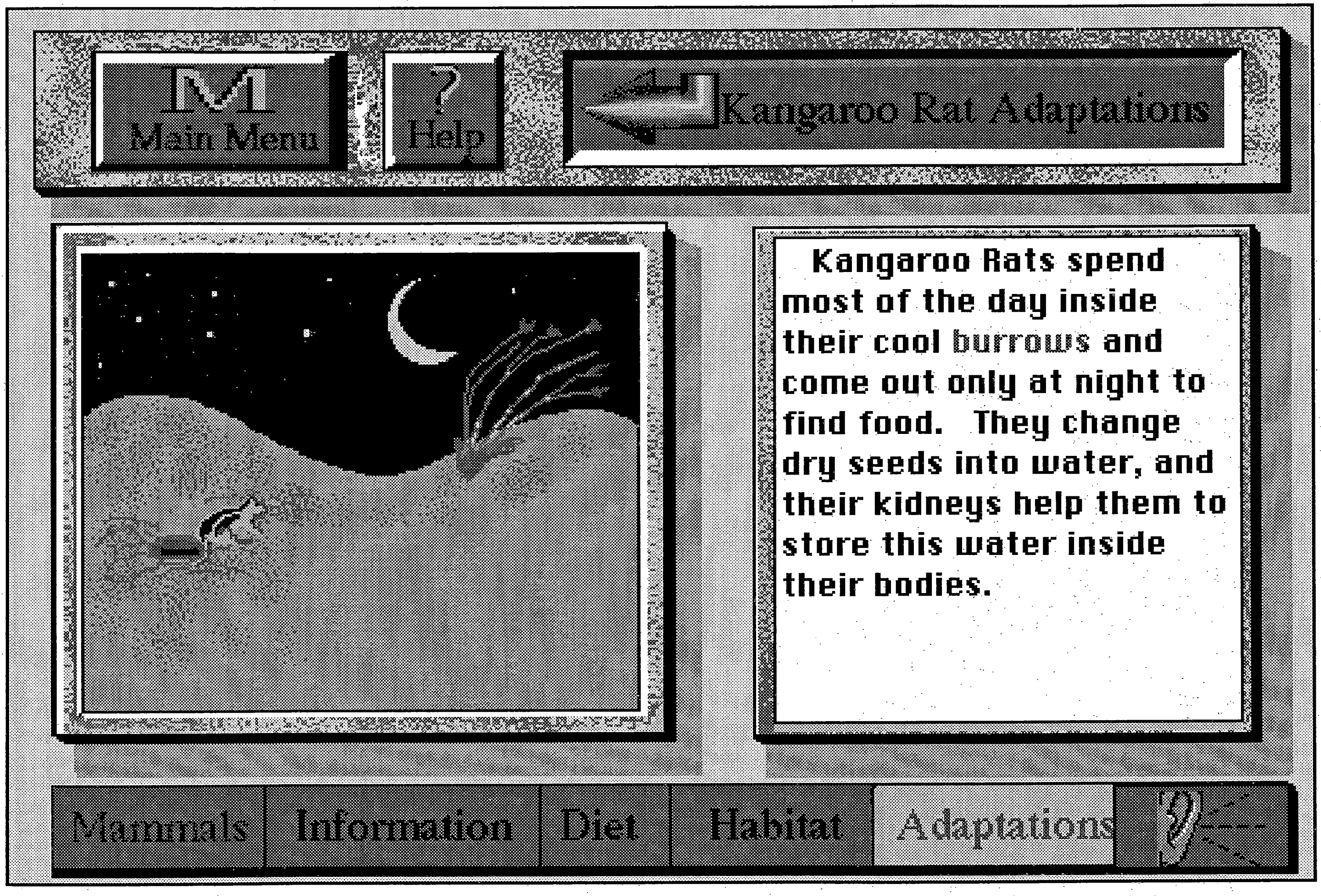


Figure 14. "Kangaroo Rat Adaptations" Animation

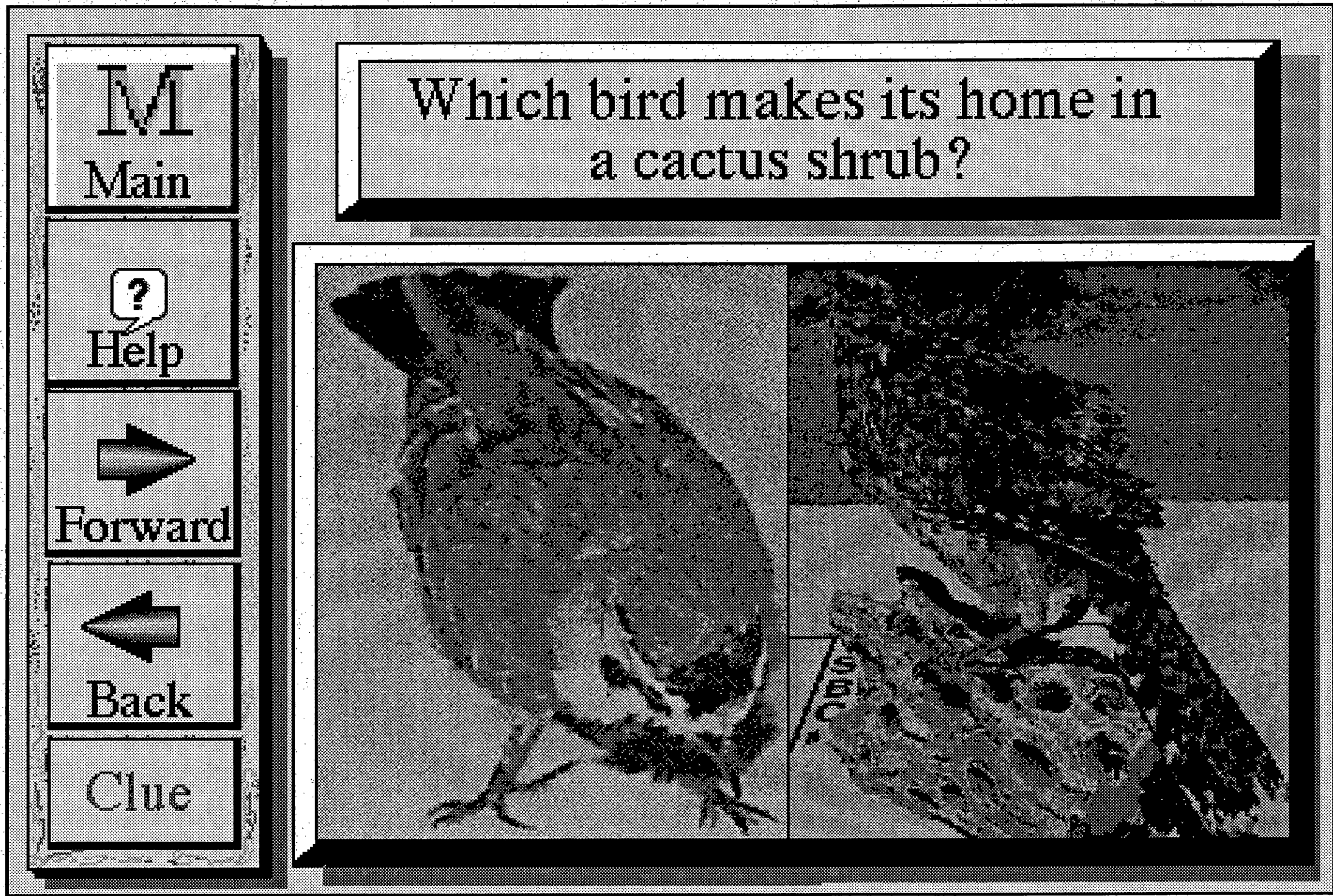


Figure 15. "Name That Animal" Activity

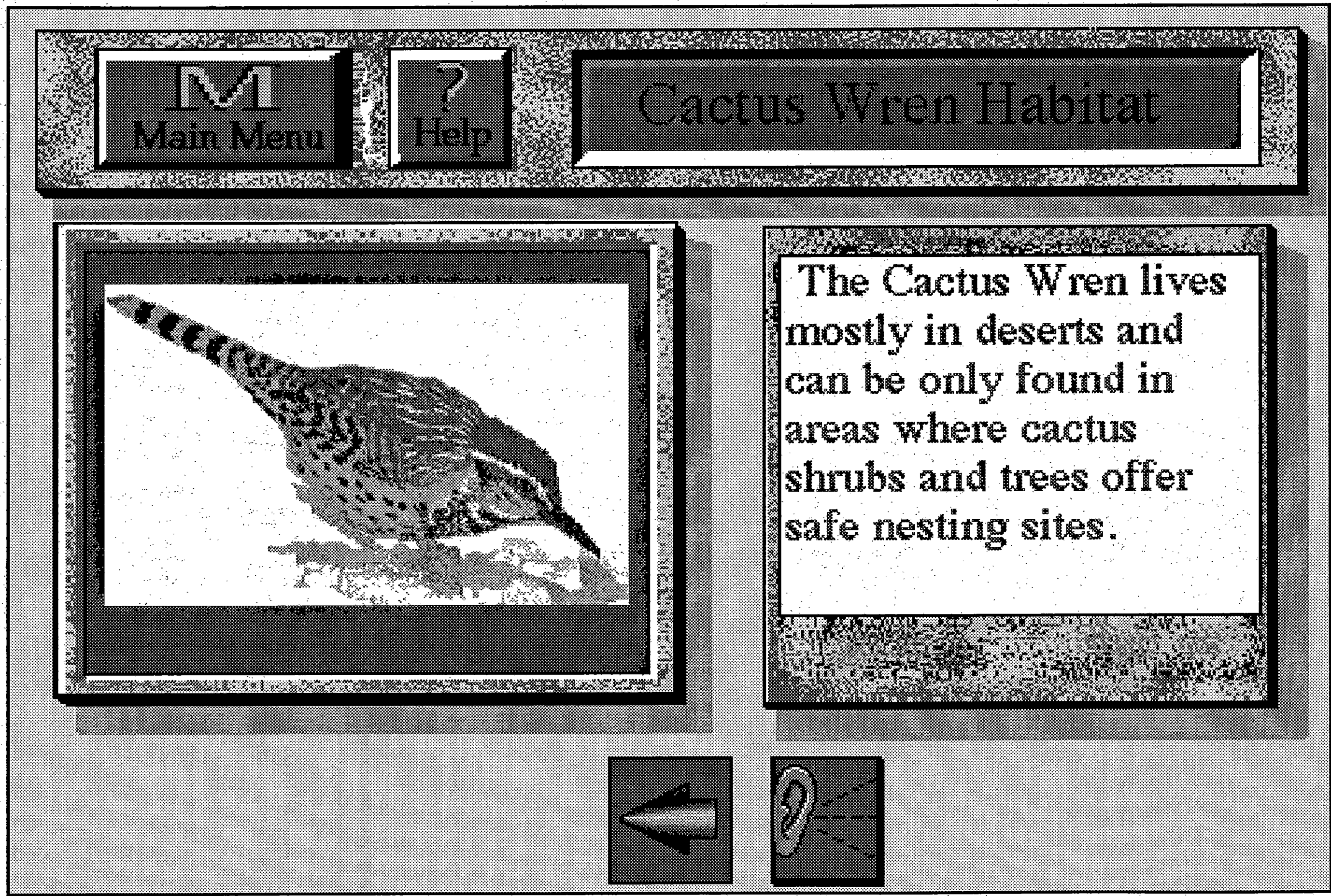


Figure 16. "Cactus Wren Clue" Card

inquiry, they hear "applause" and can move forward in the activity. In the activity "Make the Adaptation", students are provided information about their performance, and shown a graphic which demonstrates the correctness of their answer (see Figure 17). This design principle accentuates the student's understanding of their answer and reinforces the learned skill.

Enhancing student retention and transfer occurs in the final activity of the program called "Build an Animal", and also represents the project's attempt to employ problem-solving strategies into its design. In this activity students must address a problem-solving issue and demonstrate their understanding of how an animal adapts. The problem-solving task of creating an animal requires that the student successfully complete previous activities and effectively apply new learning in the project (see Figure 18). Utilizing their retrieval skills developed from the content area, students must accurately design their own desert animal and describe how it is suited to adaptation. The assessment of student understanding is observed from the printout of their work and should reflect an understanding of the basic elements for animal adaptations in the desert.

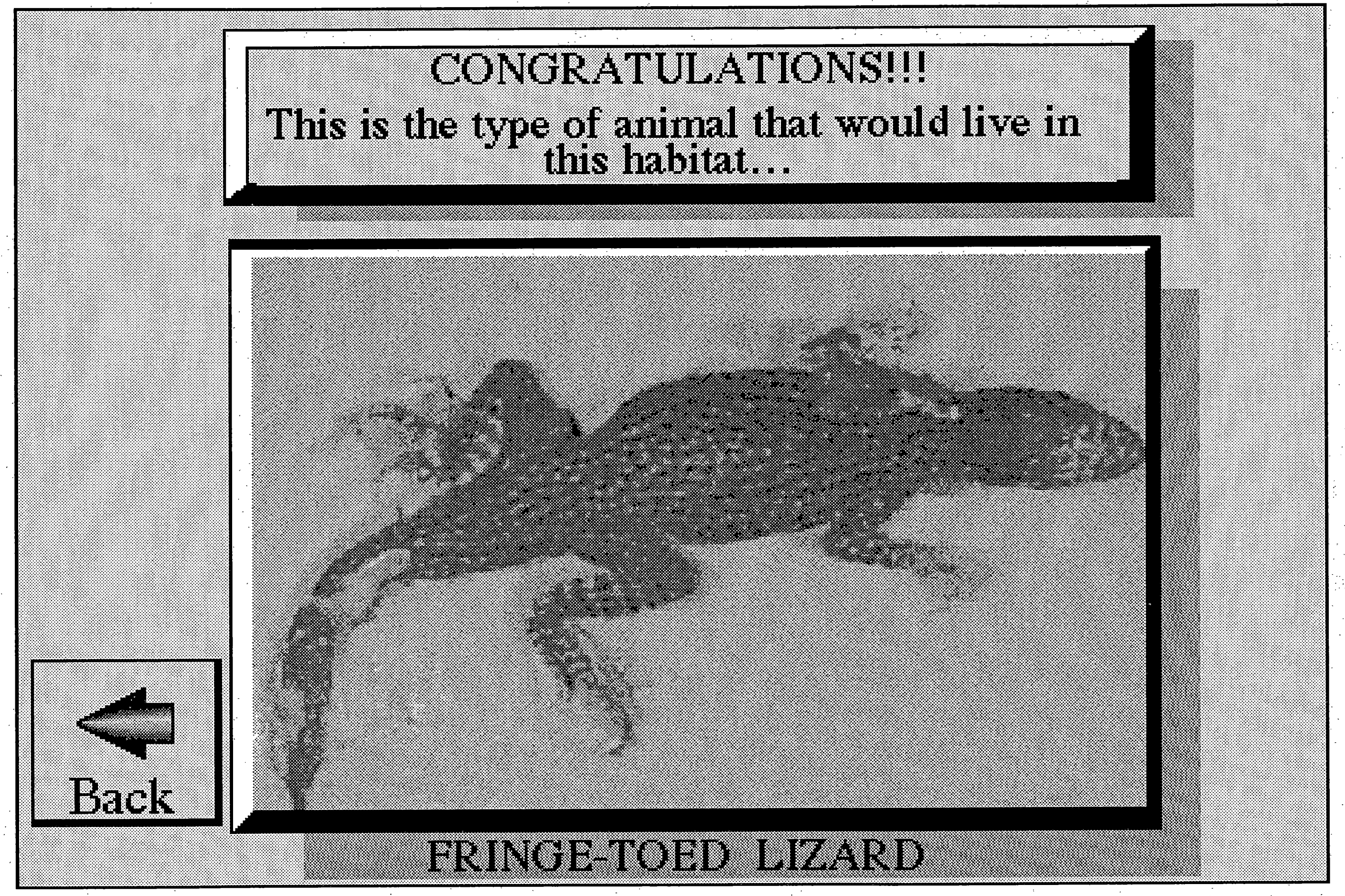


Figure 17. "Make the Adaptation" Congratulation Card

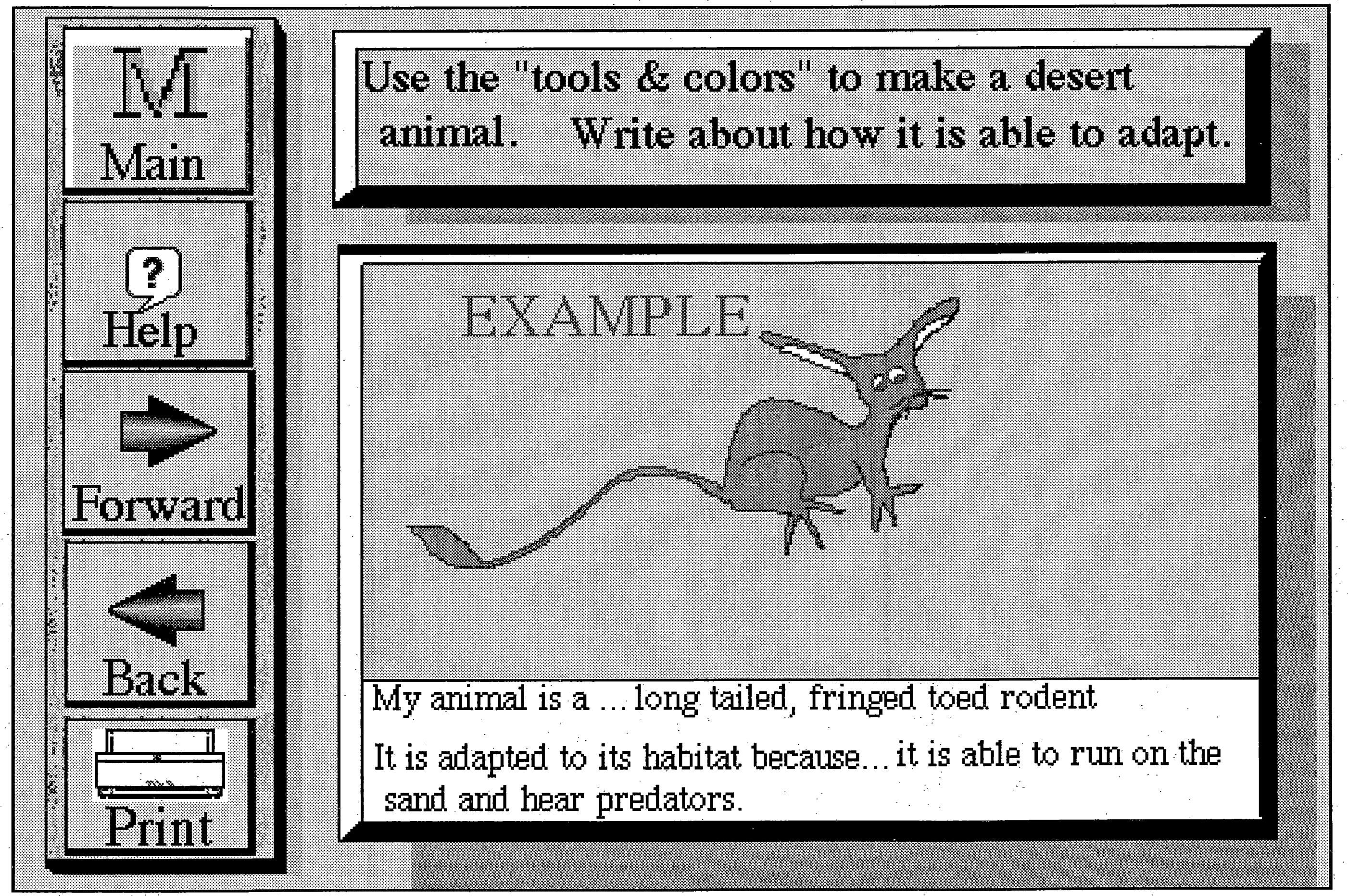


Figure 18. "Build an Animal Example" Card

Screen Design

Figure 19 shows how most cards in the project are designed. Each of these cards are linked to either the submenu or the main menu. The menu based organizer on the bottom of the screen is added to each card to help with navigation. This menu can also be used by the student to access other topic areas of the animal, ie. information, diet, habitat or adaptations. As previously mentioned, the button which is highlighted reminds the student which stack they are currently working in.

A color system is used for selective purposes and is designed to aid the student's understanding of how the project is laid out. Each animal is defined by a certain color, which is present on all of the buttons and menu bars. Furthermore, each card is formatted with similar fonts and font sizes. The relationship of button placement, menu bars and text fields on each card are also designed similarly throughout the project. This feature helps the student organize the information presented to them, and allows them to easily familiarize themselves with the project without having to learn too many steps for its operation.

Textual information is kept to a minimum to prevent overload of information and can be heard from a sound button on each card. Hypertext are used for either letting the student see different perspectives of the animal, view a

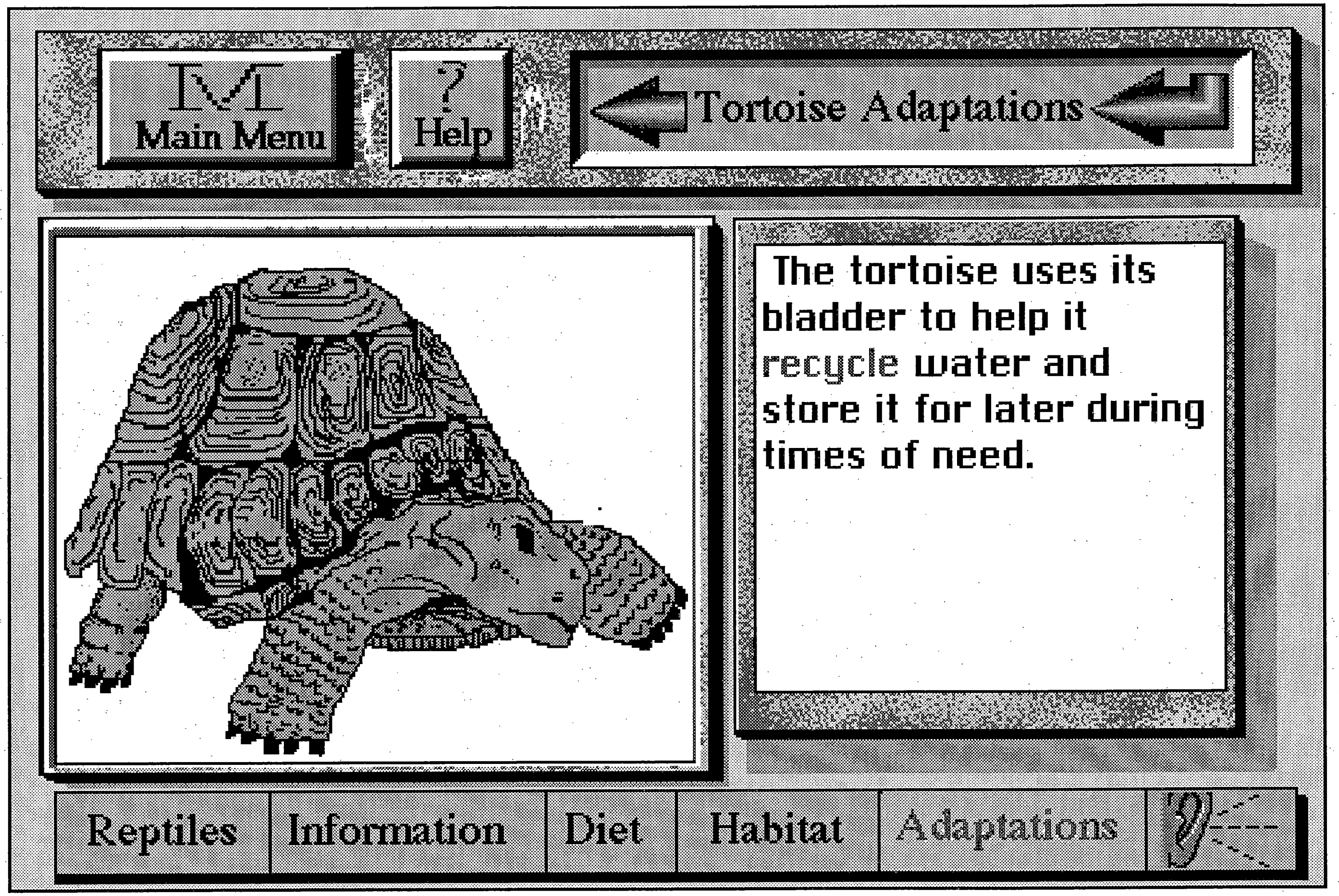


Figure 19. "Desert Tortoise Adaptations" Highlighted Text

short video clip or hear a sound. These features add interactivity to the screen and allow the student to see or hear information they would not normally get from a textbook.

Formative Evaluation

Animal Adaptations in the Desert was tested on two volunteer students in the third grade from Kimbark Elementary in the San Bernardino City Unified School district. Two boys and two girls were selected by random, and given a letter of consent to be signed by their parents before evaluations began. Two of the students served as alternates.

Each student was observed as they worked on the program during lunch and noon recesses for five days. The students were observed according to the following criteria: The effectiveness of the program's navigational design and how subjects were able to move through the program; participant responses to positive and negative feedback regarding the content area from the program; the success rate and ability of the participants to answer follow-up activity questions and complete program activities; time considerations and how long it took each participant to go through the program; and, participant responses to questions about the program upon completion of lessons and activities.

Before the students started they were given a brief tour of the project and given basic instructions about its function and design. Only one of the students had prior experience and knowledge of the Desert Habitat Study Kit which the project was based upon, whereas the other student had no experience with the study kit before. Each student worked independently on the project, and were isolated from their peers.

Upon conclusion of the evaluation each student was interviewed about the project and asked the following questions:

1. What things did you like most when working with this program?
2. What things did you like least when working with this program?
3. What did you learn from the program? (e.g. How does the Kangaroo Rat adapt to its habitat? Answers should reflect an understanding of how animals adapt to the desert.)
4. Did you have any trouble figuring out how to move through the program?
5. Which activities did you like most and least? Why?

<u>Feedback Received</u>

Both students used their own individual approach to navigating the project. One student used the "sound" icon to hear the text, whereas the other opted to read the text independently. Occasionally each student would either overlook particular buttons and move to other content areas in the project before completing all of a stack's cards, or successfully go through an entire stack. After a brief trial period, both students demonstrated a clear understanding of how to manipulate the project's navigational design and were able to successfully move through all of the project's content.

Upon observation, it appeared that each student felt more comfortable accessing topic areas using the menus from the bottom of each card, rather than the alternative route offered by the return button on top of each card (see Figure 9). Both students responded that they had no difficulty understanding how to navigate the project. Yet, one student did express that he sometimes had trouble noticing the buttons on top of the screen and the fact that more cards existed in a stack. After the initial trial run, however, he soon learned the program's navigational design and was able to complete the entire project.

Neither student expressed any particular reaction to the project's installation of sound responses for both positive and negative feedback in the "activity" section, but they did appear to look over each card for signs of animations or movies. Once they were familiar with the function of highlighted text in the project, they paid close attention to each card's text and actively scanned the text fields for signs of interactivity. One student responded that some of the animations were "cool" and wished that there were more of them in the project.

Both students had moderate trouble correctly answering some of the activity questions in the project. When presented a question about the similarities between the "Kangaroo Rat" and the "Pocket Mouse", one student asked if she had to make a response and was not sure how to answer. Both needed assistance understanding how to use the navigational system to find the answer to this particular question, and each student had difficulty distinguishing the "Kangaroo Rat's" features from the "Pocket Mouse".

Once the students were familiar with the "Activity" stack menus, they were able to have more success responding to questions. The "Clue" button was used by both students in different instances to help them make the right answer to particular questions. However, the "Make the Adaptation" activity proved to be more difficult than the other activities because of the stack's design. Each student expressed confusion about graphics in the activity which they thought were buttons, and both needed an explanation of the purpose of these graphics.

The evaluation process for this project took approximately four hours over a period of five days. Both of the students' times to complete the program varied from the other. Upon conclusion of the project each expressed that they enjoyed the experience and did not find it too difficult. The students did state that they liked the pictures, and one mentioned that it was fun because he could see how the desert environment looks. Even more, each one was excited to be among the first students to test the project and looked forward to sharing their experiences with their fellow classmates.

Revisions

Several revisions were made in relation to the feedback from the project's evaluation. To help the students understand the similarities between the "Kangaroo Rat" and the "Pocket Mouse", a different graphic of the "Kangaroo Rat" was implemented as a better reference to an analogy between the two. The "Make the Adaptation" activity was also revised. Graphics which appeared as a button to the students were designed to look less like the other buttons on the cards.

Project Strengths and Limitations

The *Animal Adaptations in the Desert* Project was designed with the intention of involving young learners in science. Its strengths come in the forms of meaningful graphics, motivating animations and useful video clips. When used as a supplement to the Desert Habitat Study Kit, it offers students an alternative source of information and activities.

The program covers a comprehensive amount of details on each of the animals in the study kit which students can directly access for their own use. Students are presented key concepts about animal adaptations in the desert, and the program utilizes computer design principles to help the student focus on new material and develop problem-solving skills. In addition, the project is designed for young learners, and presents the content to them in a language which is suitable to their needs and ability.

Limitations are found within the amount of content offered by the project. Due to the time requirements for completing this project, only a selected fraction of the animals and insects from the museum's study kits were used in its development. Students who have the opportunity to use the study kits will find that the project does not include specific plants and insects which are found in the study kits.

In addition, museum study kits are loaned to schools for a time period of two weeks. Therefore, given the vast amount of information and material in the project, some students may have difficulty successfully completing all of the project's content independently. If the project is offered as a supplement to the Desert Habitat Study Kit, it would be unlikely that all of the students in a classroom would be able to complete it in the amount of time that they are made available.

Recommendations

To maximize the learning potential that this project has to offer, it is recommended that it be shared with small groups of students rather than on a one-to-one basis. It is also required that the users have access to a "Zip Drive" device to operate the program.

When used in conjunction with the study kit, students may direct the project to research particular facts on each of the animals. Teacher guidance is important to maintain student interaction and understanding of the project's objective of having students learn about desert animal adaptations. Printouts of student work from the "Build an Animal" activity can be compiled into a book which demonstrates an understanding of how desert animals adapt.

The project could also benefit from having more interactive features such as those presented in Figure 14. Students are motivated by animations and tend to be more responsive to stacks with these types of designs, rather than those which only display text and pictures.

Conclusions

The *Animal Adaptations in the Desert* Project has proven to be an extensive and worthwhile undertaking. Even though its instructional value has yet to be methodically evaluated and tested on a large group of students, its development is an asset to a necessary cause and has been triumphantly accomplished. The need for partnerships between schools and learning institutions such as museums has been a long standing goal for many educators. This project has demonstrated how technology can help bridge the gap between schools and educational resources, and presents a computer based instructional program as the tool for doing so.

The project also successfully employs computer design learning principles which promote thinking in students about desert animals, and follows a rationale which supports theories for building problem-solving skills in students.

Upgrades to the program can be easily added over time, and provide an example of how technology can be used to enhance educational resources offered by the museum. However, the overall success of this project cannot be measured solely by its learning outcomes, but also through the relationships it helps build and establish between schools, students and the museum.

APPENDIX A

IRB Form

CALIFORNIA STATE UNIVERSITY
SAN BERNARDINO

APPROVED

Expedited Review
IRB File #
I97067

APPROVED

The California State University

May 12, 1997

Dean VonWald
c/o Dr. Rowena Santiago
California State University
5500 University Parkway
San Bernardino, California 92407

Dear Mr. VonWald:

Your application to use human subjects in research, titled, "Use of a Computer Based Instructional program to Enhance Desert Studies Kit Concepts," has been reviewed by the Institutional Review Board (IRB). Your application has been approved. Please notify the IRB if any substantive changes are made in your research prospectus and/or any unanticipated risks to subjects arise.

Your informed consent statement should contain a statement that reads, "This research has been reviewed and approved by the Institutional Review Board of California State University, San Bernardino."

If your project lasts longer than one year, you must reapply for approval at the end of each year. You are required to keep copies of the informed consent forms and data for at least three years.

If you have any questions regarding the IRB decision, please contact Lynn Douglass, IRB Secretary. Ms. Douglass can be reached by phone at (909) 880-5027, by fax at (909) 880-7028, or by email at ldouglas@wiley.csusb.edu. Please include your application identification number (above) in all correspondence.

Best of luck with your research.

Sincerely,

Joseph Lovett, Chair
Institutional Review Board

JL/ld
cc: Rowena Santiago, Science, Mathematics, and Technology Education

5500 University Parkway, San Bernardino, CA 92407-2397

APPENDIX B

Animal Adaptations in the Desert - The Disk

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