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ABSTRACT

This study investigated the use in junior high schools of a prototype interactive videodisc, "Seeing the Unseen." The experimental disc contains four lessons designed to teach scientific inquiry skills. Students determine the order of the lessons and interact with the disc by touching the screen to pause, replay, see a series of questions or examples, return to the menu, or move ahead. "Seeing the Unseen" was used to explore five aspects of videodisc technology: (1) the importance of user control and interactivity; (2) the importance of high quality visuals; (3) the potential of the videodisc for promoting inquiry learning; (4) the effectiveness of individual, small group, and whole-class instruction; and (5) the teacher's role in using videodisc technology. Students found it easy to use the disc, and they appreciated the high level of participation and control that it offered them. It combined the dramatic qualities of television with the self-pacing available through books and educational software, and they credited high quality visuals with contributing to the technology's appeal. Most teachers felt that the technology encouraged them to act as a guide or facilitator, although many had difficulty acutally assuming that role. (Appendixes present the student and teacher questionnaires, and sample worksheets.) (Author/CW)

TR87-4

A PROTOTYPE SCIENCE INTERACTIVE VIDEODISC: RESEARCH ON IN-SCHOOL USE

Technical Report

April 1987

Educational Technology Center
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A PROTOTYPE SCIENCE INTERACTIVE VIDEODISC RESEARCH ON IN-SCHOOL USE

TECHNICAL REPORT

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I. INTRODUCTION

The ETC New Technologies Group is charged with examining the educational implications of emerging technologies. These technologies are not yet widely used in the nation's schools but show considerable future promise Prominent among these new technologies is the interactive videodisc. The Videodisc Research Group, a subsection of the New Technologies Group, was formed to conduct research on questions related to the design, application, and evaluation of videodisc technology.

The group designed and produced a research videodisc, SEEING THE UNSEEN, to study the application of interactive videodisc technology to science education in middle schools. The videodisc was created using existing video segments from NOVA and 3-2-1 CONTACT and an authoring system, Authority (TM), developed by Interactive Training Systems, Inc.

Through the design of the research videodisc the group investigated the potentials and constraints of videodisc creation through retrofitting. Our conclusions regarding this process are described in our technical report, The ETC Science Videodisc Project: A Report of Research in Progress (Educational Technology Center, July 1985). In the present report we describe our research on the use of the prototype videodisc in middle school science classrooms. Our research explored the validity of a variety of assertions commonly made regarding videodisc use in schools

ABSTRACT

This study investigated the use in middle schools of a prototype interactive videodisc, SEEING THE UNSEEN Designed and produced by ETC researchers, the experimental disc was used to explore five aspects of videodisc technology: 1) the importance of user control and interactivity; 2) the importance of high quality visuals; 3) the potential of videodisc for promoting inquiry learning; 4) the effectiveness of individual, pair, and whole-class instruction; and 5) the teacher's role in using videodisc technology. Of 116 middle school students, 86 participated in whole-class sessions, 12 used the disc individually, and 18 used it in pairs. Researchers observed students as they proceeded through the lessons, noting their strategies and their difficulties, as well as their interactions with each other and with their teacher Interviews and questionnaires elicited student reactions to the technology and informally assessed their grasp of the concepts and skills presented. Teacher interviews probed the teachers' perceptions of the lessons and of the classroom implications of the technology.

Students found it easy to use the disc, and they appreciated the high level of participation and control that it offered them They felt that it combined the dramatic qualities of television with the self-pacing available through books and educational software, and they credited high quality visuals with contributing to the technology's appeal. Students in all use modes enjoyed the disc and understood many of the concepts and skills presented Most said they would prefer using the disc in pairs, a use mode which offers a high degree of user control as well as ample opportunities for social interaction and support. Teachers used the technology in a variety of ways: some let the videodisc lessons stand alone, some provided supplementary material, and some used the disc as a tool in their own lessons. Most felt that the technology encouraged teachers to act as a guide or facilitator, although many had difficulty actually assuming that role.

These results support the potential of videodisc as a medium for science education. The technology permits students to control the pace and path of their learning, and it allows a combination of moving color images, music, voice-over explanations and instructions, and screen display of text and graphic information Videodisc may hold particular promise for teaching hard-to-visualize concepts, providing access to phenomena that occur only in remote locations or cannot be observed with the unaided eye, or simulating experiments that require complex and expensive laboratory equipment.

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II. RATIONALE

Reviewing videodiscs currently in use and the related research, we identified a variety of assertions about both the nature of the videodisc medium and the type of learning experience that it affords. These assertions are sometimes supported by research findings, but are often based on opinions regarding the promise of the technology They range from the almost universally held opinion regarding the importance of highly produced visual images to more divergent views on effective modes of utilization

Using SEEING THE UNSEEN as an example of videodisc technology, we set out to examine the validity of these assertions as they applied to the use of a videodisc in middle schools. SEEING THE UNSEEN was designed to be especially appropriate for use with middle school science students. Attention was given to developing a disc that was consistent with the curricula and teaching styles found at this grade level. In addition, the disc was developed as a design sampler, with four lessons that illustrate a variety of videodisc presentations and interactions. This design allowed us to explore the areas most likely to benefit future development of educational videodisc:

- The importance of interactivity and user control

Much has been written about the interactive potential of videodisc technology. Interactive videodisc systems can afford users a sense of control and independence in learning. In describing this type of active, self-paced learning environment, Gibbon (1983) asserts that, "If the user does have control of the environment, there is an exhilarating sense of power that accrues to the experience Learner control of the learning environment seems most important, perhaps instrumental, in improving the quality and the quantity of the learning that takes place there"

(p.5) Such control is thought to enhance learning by imparting a sense of power and freedom to the user Kearsley and Frost (1985) suggest that "the more control students feel they have, the more involved they will be in the instruction" (p.11). Others have added that active involvement increases learning (Cohen, 1984)

Some authors argue that user control helps students take responsibility for their own learning by allowing them to pursue their own most effective learning strategies, reviewing difficult concepts and skipping those with which they are familiar (Cohen, 1984; Gibbon, 1983; Nugent & Stone, 1980). Others have cautioned, however, that too much control might actually interfere with a student's learning progress. Cohen (1984) has suggested that extensive user control, especially in the hands of less competent and confident students, might be misused, resulting in inappropriate or ineffective decisions regarding their own learning process In addition, Karwin, Landesman and Henderson (1985) have noted that the sheer variety of videodisc options could reduce "a carefully-designed lesson to a confusing and ultimately ineffective experience for the learner" (p.60)

Given these two arguments, the videodisc group explored the impact and significance of control and interactivity to users of the SEEING THE UNSEEN videodisc.

- The importance of high quality visuals

In their article, "Design Factors for Successful Videodisc-Based Instruction," Kearsley and Frost (1985) argue that "Videodisc is an inherently visual medium. The impact and effectiveness of a videodisc will depend heavily on the quality of the visual design" (p.10). Much of the literature describing videodisc technology highlights the visual aspect as an important advantage over more traditional instructional methods The capacity to present provocative, realistic, and high quality images is often cited as a unique instructional quality, contributing to

user interest and motivation (Bunderson, Baillo & Olsen, 1984, Kearsley & Frost, 1985, Levin, 1985) In addition, some researchers have argued that intriguing, high quality visuals are critical contributors to active learning with videodiscs (Bunderson, Olson & Baillo, 1981; Davis, 1984; Glenn & Kehrberg, 1985; Tobin, 1984)

The quantity of visual images made available through the technology is also considered important (Char and Talley, 1986) As Levin points out, the images provided by the motion picture camera can "bring the 'real world' directly to the learner and portray much of the color, excitement and immediacy that actual 'hands-on' experience in the natural environment can provide" (Levin, 1985, p.1).

Some have noted that visual presentations are curiously absent from today's classrooms: "our classrooms have become barren, left-brain deserts, filled with words and symbols that are divorced from the images and events they represent. This has happened even though people seem to crave and respond strongly to visual images Students in our project seemed hungry for the videodisc to balance the skewed verbal diet of academia with a rich supply of visual images" (Bunderson et al., 1984, p.178).

In light of these assertions, we explored the importance of the visual presentations to users of SEEING THE UNSEEN

- <u>The potential of interactive videodisc as a teaching tool for inquiry learning</u>

It is asserted that the kind of learning that takes place while using interactive videodisc should be different from that fostered by other educational media or which takes place in a traditional classroom. Given the more participatory and self-paced learning experience offered by the technology, Bunderson et al. (1984) believe a qualitatively different kind of learning would be made possible. Indeed, it would seem that the uniquely interactive nature of the technology could serve to encourage a more active.

inquiry-oriented type of learning process. This type of learning experience has become increasingly vital as we move away from the notion that educated people are sorters of facts, replacing it with the assumption that, "educated people are really problem solvers and decision makers, capable of handling what-if assumptions, complex models and variable outcomes" (Emmett, 1984, p.62)

The discipline of science seems particularly appropriate for utilizing the videodisc as a tool in encouraging skill building and practice. As we observed in our technical report, The ETC Science Videodisc Project: A Report of Research in Progress, "Science education introduces new ideas, provides a paradigm for thinking and analyzing problems, and nurtures curiosity about the natural world. The videodisc medium's unique strengths-- interaction with and management of audio, visual, and textual information--and unique applications of instructional strategies, indicate that it may be ideally suited to the task of science education" (Educational Technology Center, July 1985 [a], p.9).

Through its ability to present a wide range of "real world" models and experimental simulations, videodisc can promote active involvement in a variety of scientific explorations. Thus, students are encouraged to hone the various skills associated with such explorations. These skills include: decision making; problem solving; creating; observing; and evaluating. SEEING THE UNSEEN was designed to employ such an inquiry approach to science education.

In our current research, we explored students' ability to understand and engage in this approach and the inquiry processes involved and further, whether they could apply such scientific exploration techniques as a result of their interactions with the disc.

• The potent different r e modes

Much of what has been written about videodisc technology categorizes it as a successful and long overdue tool for individualized instruction (Buterbaugh, 1980; Hunka, 1982; Nugent & Stone, 1980). Such instruction has been defined as "a one-on-one form of instruction that considers the learner's background, interests, aptitudes, abilities, and needs to impart defined knowledge, skills, and attitudes in the most efficient and effective manner possible" (Oliver, 1985, p.3). Through its uniquely interactive options and potential for user participation, videodisc technology is capable of providing such an instructional format. As Jay (1985) writes, "The real value of computer instruction is to teach to each individual's level of comprehension" (p.25). Individual students using the videodisc are afforded the opportunity to pursue their own learning strategies at their own pace. Given the ever increasing demands of teachers in large classroom situations, the videodisc would appear to provide useful curricular enrichment to individual students.

There is controversy, however, over whether individualized learning is necessarily the most appropriate use of the technology. Hofmeister (1985) points out, "There is a tendency for many in instructional technology to assume that the individual learning station is the most powerful instructional delivery system and the acceptance of anything less occurs because of a lack of resources. The widespread acceptance of this assumption suggests that there is a wealth of research to support the clear, comparative advantage of the individual learning station over - her instructional delivery systems. Such is not the case" (p.5). He argues that research findings actually indicate that group-paced systems, including peer tutoring, have been shown to be equally effective instructional delivery systems and concludes that "individual learning stations

must not be viewed as the ultimate delivery system for the public school" (p.6).

In support of this argument, a study conducted during a Florida-based videodisc training project found that some trainees working at individual stations would pair themselves with others, agreeing to maintain the same progress rate and discussing the details of the training together (Smith, 1985). Smith observed that pairs' discussions, "often included teaching and learning within the pair, which serves as a fresh reminder that individualized training can often receive help from peer discussion" (p.25). Others argue that, "a videodisc system seems to work best when used by a small number of students (two or three)" (Fuller, 1985, p.43).

Finally, additional literature supports the view that videodisc may be used in a variety of modes. In their report on four classroom case studies of videodisc use in classrooms, Char and Tally (1986) found that "large-group instruction and small-group learning with the videodiscs each had an important place in classrooms" (p.16). Lipson (1978) concurs, explaining, "one can imagine conventions of using a videodisc with pairs of students, a group of students, or with a teacher conducting an entire class" (p.282).

These varying assertions led us to explore what happened during individual, pair, and classroom videodisc use and the use mode preferences of both students and teachers.

- <u>The teacher's role in the use of videodisc</u>

The research literature has also devoted attention to the role of the teacher in educational applications of videodisc technology (Gibbon, 1983; Glenn, 1983; Levin, 1985). In general, articles suggest that the teacher's role may undergo change as a result of videodisc use; this change would be positive in nature and result in more effective and successful educational experiences

Rather than as a replacement for the teacher, the videodisc is often viewed as an instructional tool, at the teacher's disposal (Glenn, 1983; Hofmeister, 1985). The interactive nature of the videodisc is inherently different from the majority of the more traditional instructional tools and methods employed by teachers As a result, it has been suggested that some adjustments might be required on the part of the teacher, as well as the student. "As the disc is used, new roles will emerge for both the student and the teacher because the use of technology is not neutral, it impacts rather directly on the users" (Glenn, 1983, p.330).

With the potential for students to take more responsibility for their own learning experiences, the teacher who utilizes the videodisc in his or her classroom may serve as a guide in students' learning experiences, "setting the context for, facilitating, and extending this student-guided, disc-based inquiry" (Char & Talley, 1986, pp.1-2). Indeed, it is suggested that the success of a learning experience which utilizes computers and television is dependent on "the skillful role of the teacher as the ultimate package facilitator--a teacher who is willing to take an 'intellectual adventure' with the students as well as discard the role of didactic lecturer for that of a knowledgeable collaborator" (Educational Technology Center, July, 1985 [b]).

To study the role of the teacher when a videodisc is used with a whole classroom group, we explored the ways in which four teachers used videodisc in their classrooms.

By investigating these assertions about videodisc technology and their relevance to in-school applications, we hoped to gain a deeper understanding of the potential for the use of videodisc technology in schools. Accordingly, our study was designed to answer the following research questions:

1) What is the nature and extent of the impact of user control and interactivity on users' experiences with the videodisc?
2) To what extent do high quality visual images affect users' experiences with the videodisc?
3) What is the potential of videodisc technology as a teaching tool for inquiry learning?
4) How appropriate are individual, pair, and classroom use modes for in-school videodisc use?
5) What is the role of the teacher in utilizing videodisc technology in a classroom setting?

III. DESCRIPTION OF SEEING THE UNSEEN

SEEING THE UNSEEN employs an inquiry approach to science education, an approach in which students explore and inquire as scientists do, rather than simply being presented with scientific information. The disc provides an environment or microworld in which students can carry out investigations.

Students hone various techniques associated with scientific explorations through their interactions with four lessons. These techniques include: making observations; collecting, recording, and classifying data; seeking patterns; forming and refining hypotheses; conducting experiments; and making predictions. The techniques are not practiced independently from each other and are not viewed as separate or linear steps in a problem solving process. Some, but not all, of these techniques are required for each lesson.

Each of the four lessons focuses on a different problem posed as a question. While the lessons present topical information (plants and light, animal camouflage and mimicry, time and motion, and the geometry of shapes), the value of each lesson is derived from using a variety of scientific exploration techniques to examine the subject matter. The problem-solving methods required vary from lesson to lesson depending on the teaching strategy employed and the mode of inquiry elicited.

The four lessons take advantage of the many forms of interactivity available with Level 3 videodisc technology. Computer control of the videodisc permits branching based on students' responses, use of two audio channels, random access to visuals and automatic search, and the presentation of text screens as well as text and graphic overlays. Specific interactive options built into the lessons include video pause (freeze-frame), video replay (forward or backward), redo (return to an earlier activity),

menu (go back to the last menu), and go ahead (go to next menu, screen, or activity). In some lessons, students can also choose to view charts, lists of thought questions, or additional information The user controls the system primarily by touching the screen, although there are some instances when keyboard input is required

A description of each videodisc lesson follows

A. "How Does Light Affect Plants?"

This lesson, also referred to here as "Plants and Light," consists of three sections: "Introduction," "Experiments," and "Prediction Questions." The "Introduction" provides general background information about plants and light and presents issues related to each of the three simulated experiments that follow.

In the "Experiments" section, students investigate different aspects of light and plant growth in a laboratory setting and then record their observations on charts with pencil and paper. Although students are given printed charts to use during the lesson, they may also choose to view sample charts as graphic screens on the videodisc. The interactive options of the videodisc allow students to manipulate variables in the controlled experiments and replay video to observe events more than once.

The first experiment asks students to change the position of the sun and observe the reactions of growing plants; the second experiment asks students to change the color of light (red, blue, or green) and observe the effects on three plants; and the third experiment asks students to cover or cut the tips or stems of plants and observe subsequent plant growth. The "Prediciton Questions" at the end of the lesson ask students to apply new knowledge they have gained in the experiments by determining the outcome of several "what if" questions.

The lesson is intended to help students learn to conduct controlled experiments and manipulate independent variables to observe changes in a dependent variable. In addition, students

learn to make observations and record them systematically and form predictions based upon their observations. When making predicitions, students generalize from specific situations to hypothetical cases that involve several critical variables

B. "What Disguises Do Animals Use?"

"Animal Disguises" provides the tools and subject matter for an investigation into forms of animal mimicry The three sections in the lesson include "The Great Pretenders," "Disguise Parade," and "What's Hiding?" As a video introduction to the lesson, "The Great Pretenders" illustrates cases of camouflage and mimicry among animals and presents them as strategies that aid in survival.

"Disguise Parade" consists of twelve video sequences on animal behavior that depict the effects of camouflage and mimicry on predator-prey relationships. In this section students may play and replay the video sequences as needed, and create a chart with pencil and paper to categorize animal disguises. Each student is provided with a sample chart and a list of thought questions (called Notes) for recording data, both of which are also available as visual displays on the videodisc.

In "Disguise Parade," students observe the video sequences and take notes on the animals and their disguises. While viewing the first set of six sequences, students look at their notes for patterns in animal disguises and make charts categorizing the disguises. Students then view the second set of six sequences and see if their classificaion schemes apply to the animals in the new scenes. Following the twelfth sequence, students are asked to review their charts and make any changes that they feel are necessary. They are then given the option to see how one scientist has categorized animal disguises.

What's Hiding?" is the final section of the lesson and consists of an observation game that challenges students to find and touch the heads of camouflaged animals. The game takes full

advantage of the technology's ability to produce appealing touchscreen images. Students interact with the system as they attempt to identify the hidden animals and are encouraged in their trial and error experimentation by the game's playful approach

The lesson is designed to encourage students to identify critical visual data through careful observation. Students also learn to record their detailed observations and organize the information in charts. In addition, students form categories by generalizing from specific cases and recognizing analogous situations. Once they devise a classification scheme, students also learn to test their categories by determining whether new data fits an established category or represents a new one. Finally, students must determine whether they can refine categories or must devise new schemes that are more useful in describing and organizing their data.

C. "What Happens When Time Is Altered?"

This lesson, dubbed "Edgerton" after Dr. Harold Edgerton, inventor of the stroboscope, includes an introduction and three exercises that illustrate how altering the perception of speed and motion can reveal new information about everyday events. Although the lesson can be enjoyed by students working alone or in small groups, it is designed as a teacher-directed activity that will generate discussions about differences in perception and hypotheses about formerly undiscernable events.

In the introduction, "Doc Edgerton's Seeing Machine," Dr. Harold Edgerton shows how filming an event at high speed with a strobe light and later projecting the film at regular speed appears to slow down time and reveals previously unseen properties.

In the first exercise, "Everyday Events," students view four events filmed at both regular and high speeds. Due to the videodisc's interactive capabilitites, students can play and replay each event to study the new information revealed when an action is

viewed at different speeds Students are given a worksheet with a list of thought questions at the beginning of the exercise to help them form hypotheses about the relationships between time and motion. These questions are also provided as a text screen that students may choose to view.

In "Milk and Water Drops," the second exercise, students can play and replay, both forwards and backwards, high-speed films of milk dripping from a container to a cup and water falling into a pond; the milk and water drops are two examples of the same phenomenon. Students are given a handout of thought questions, which they can also access from the touch-sensitive screen, that encourages them to identify and make hypotheses about the physics of liquids in motion.

The last exercise, "Altered Time," presents students with a video collection of high-speed and time-lapse clips. Students are given a handout of a chart listing the video sequences and are asked to indicate whether each is a high-speed or time-lapse action. Students can replay or pause clips as often as needed.

In this lesson, students observe in order to investigate the nature of time and the underlying charateristics of common events. Students learn to recognize patterns in phenomena and make predictions based on the similarities they notice. The lesson encourages students to consider different frames of reference, explore new data, and form hypotheses from observations

D. "How Do Scientists Study Things They Can't See?"

This lesson, dubbed "Pauling" after Dr. Linus Pauling, contains an introduction, an interactive tutorial, and a computer simulation that lead students to consider how scientists study phenomena they cannot readily observe. The introduction is entitled, "What's in the Box?" and presents an excerpt from a 3-2-1 CONTACT program in which two children are trying to determine what type of object is enclosed in a small box.

The tutorial section of the lesson that follows is entitled "Thinking With Doctor Pauling." In it, Linus Pauling must deduce the shape of a three-dimensional block inside a closed box. The tutorial is divided into nine video clips that show Pauling thinking out loud as he determines the shape of the hidden block Each video clip is supplemented by additional information called Thoughts, which students may choose to view, that elucidates Pauling's method by describing his assumptions, providing background information, and illustrating why he eliminates specific shapes. The Thoughts section takes advantage of the videodisc's interactive options by presenting text screens and text and graphic overlays to illustrate Pauling's reasoning process.

The last section of the lesson is a computer game, "Baffles," designed to interest students in solving a problem similar to Dr Pauling's. It contains an introduction which students complete before moving on to the actual game. In the game, one to five mirrors are positioned in a covered box by the computer. Students are asked to determine the locations and orientations of the mirrors by shooting beams of light through the box from numbered points along its top, bottom, and sides. Students shoot light beams by typing numbers into the computer board that correspond to the numbers along the box's x and y axes.

The way the light beams exit the box indicate the positions and orientations of mirrors inside the box. Based on this observable feedback, students make and test predictions about where the mirrors are placed. The interactive technology gives students the opportunity to experiment with the box, as Pauling did, and use logical, deductive reasoning to reach conclusions.

Several techniques of scientific investigation are emphasized in this lesson. Students must understand a problem, form hypotheses, determine avenues of investigation by isolating variables, and conduct systematic observations. As the result of their experimental evidence, students may form alternative

hypotheses before they reach their conclusions Students learn to work with accumulated evidence and recognize when enough data has been collected to solve a problem

IV. METHODS

A. The Research Design

The research was exploratory and included observation of what actually transpired when students and teachers used the videodisc as well as follow-up interviews with students. In addition, questionnaires explored students' and teachers' perceptions and reactions to the videodiso and its lessons.

Our research examined the use of the videodisc in middle school science classrooms in three use modes: individuals, pairs, and whole classroom groups led by a teacher. The three use modes chosen represent the ways the videodisc will most likely be used in schools. We explored how students in different use modes interacted with the videodisc and reacted to it as an educational tool. We investigated the variety of ways teachers might use the videodiso with whole classroom groups. Investigation into each of these areas provided a framework for understanding the videodisc medium and the potential strategies for its implementation in middle school science classrooms.

For our study 116 students were selected to participate from two schools in the Boston area (a suburban junior high and an inner city middle school). Of these students, 86 interacted with the disc in a classroom setting (4 classes used), 12 students interacted individually, and 18 students interacted with the diso in pairs. All students were observed as they interacted with the disc on two separate occasions with two different lessons. Following each lesson, all students in the individual and pair modes, as well as a sample from the classroom group (13 students) were interviewed about the lessons. A second interview was conducted (following the second session) in which students were questioned about their reactions to the use of the videodisc

system. Students in the classroom group who were not interviewed as well as their teachers, replied to written questionnaires

B. Sample Profile

The study participants from the suburban junior high school were predominantly white and from the upper-middle income level, but included a handful of students from diverse ethnic and socio-economic backgrounds. The population from the inner-city school included wider representation of minorities and lower income levels. This school participated only in the classroom use mode

Teachers' reports indicated that 47% of the students in the study were of high ability level, while 47% were of medium ability and 6% were of low ability. In total, 86% of the students were from the suburban school and 16% were from the inner-city school Of the 43 students interviewed, 20 were boys and 23 were girls; 30 were in the seventh grade and 13 were in eighth grade; 36 were from the suburban school and 7 were from the inner-city school.

C. Instruments and Procedures

We used five instruments in our study: Observation Data Sheets, Post-use Interviews, Lesson Interviews, Student Questionnaires, and Teacher Questionnaires. (Samples of these instruments are included in Appendix A.) We refined our instruments during two phases of pilot testing with a total of 9 individuals and 2 pairs of students.

• Observation Data Sheets- These were designed for recording data on how students used the videodisc system, including their strategies for proceeding through the lessons, their use of interactive features, their interactions with other students or the teacher, any difficulties they encountered, and their reactions to

system use. All student comments, areas of difficulty, apparent insights, discussions, and interactions were documented.

• Post-use Interviews- These interviews were designed to explore students' perceptions of the videodisc, their likes and dislikes about the system and the lessons, their reactions to lesson content, and their use experiences and preferences.

• Lesson Interviews- These interviews were designed to explore how students understood and interpreted both the basic concepts and the scientific methods presented in each lesson, and to explore the ways they applied these scientific methods to the lesson activities and to analogous problems presented in the interviews.

• Student Written Questionnaires- These questionnaires were designed for students who were not interviewed. They explored the same topics covered in the Post-Use Interviews with three alterations. First, several questions were omitted that might elicit short or vague responses from students. Second, this questionnaire covered some topics regarding lesson content, including students' feelings about their comprehension of lessons and what they thought they learned from the lessons. Third, an additional question asked students to pick which of the two lessons they liked the best.

• Teacher Written Questionnaires- A written questionnaire was designed to elicit teachers' reactions to both the lessons and the use of the videodisc system with students.

Our observations and interviews were conducted by five researchers over a twelve-week period. Following four weeks of instrument pilot testing, we collected data on individuals and pairs of students in the first six weeks of the study and information on classroom use during the final two weeks.

Due to limitations on the number of science periods that students could miss while they were participating in our study, students in all use modes (n=116) were assigned to work on only two

lessons from the four available on the disc; 54% were assigned "What Disguises Do Animals Use?" and "How Does Light Affect Plants?"; 46% were assigned "How Do Scientists Study Things They Can't See?" and "What Happens When Time Is Altered?" In total, 7 individuals, 10 students in pairs, and 46 students in classrooms (two classes) completed the former pair of lessons; 5 individuals, 8 students in pairs, and 40 students in classrooms (two classes) completed the latter pair.

As described below, all students were observed using the lessons. All individuals and pairs partioipated in Lesson and Post-use Interviews as did selected students from the classroom mode. There was a slight variation in the number of students responding to some questions due to time limitations or questionnaire revisions. Following is a brief description of the procedures employed in each use mode.

• Individuals and Pairs

For our evaluation of individual students and pairs of students, two videodis systems were set up in small, private rooms and used concurrently during data collection. All sessions and interviews were tape-recorded.

When a student used the videodiso alone, one observer was present. When two students used the videodisc system together, two observers were present. For the second lesson, an effort was always made to have the same observer or observers present as during the first.

Following the first lesson, an observer administered the first Lesson Interview. After the second lesson, an observer conducted the second Lesson Interview and then the Post-use Interview. Pairs of students were separated for their Lesson and Post-use Interviews.

The observers gave students a short introduction to the videodisc system and the lessons Observers briefly explained the

technology of the videodisc system, how to touch the screen and what lessons to complete, but gave no other use directions. The observers asked students to express their thoughts aloud as they proceeded through the lessons. Otherwise, students were told to use the videodisc system as if the observers were not present. In addition, pairs of students were told to work together or alone as much as they wished.

• Classroom

The observation and interview procedures were identical for both the suburban and the inner-city classroom sessions. At each school, the classes were observed completing different pairs of lessons. Teacher A's and Teacher C's classes worked on "What Disguises Do Animals Use?" and "How Does Light Affect Plants?", Teacher B's and Teacher D's classes worked on "How Do Scientists Study Things They Can't See?" and "What Happens When Time Is Altered?"

Four observers were present for each lesson and were assigned to different tasks, including: 1) recording the teacher's comments; 2) recording the students' comments; 3) recording the touchscreen hits; and 4) recording general classroom interaction. All of the observers recorded data on their observation sheets minute-by-minute, and each class session was tape-recorded.

We gave brief directions to all of the teachers before they presented the lessons to their students, asking them to teach the lesson in the order that we had established, with some type of instructional context, and to distribute the worksheets as we had done with the individuals and pairs. Prior to their class presentations, all of the teachers had spent from 1 to 4 hours familiarizing themselves with the videodisc system and the lessons.

V. Results

The following sections present our findings regarding the five issues and related assertions discussed in the Rationale section

A. The Importance of Interactivity and User Control

Overall, students and teachers enjoyed using the videodisc system. Their enjoyment can be traced to the interactive nature of the medium and users' identification of this quality as unique and positive. While using the system, students were able to exploit a variety of the disc's interactive options. The high level of participation and control afforded by the videodisc was cited by users as the major factor contributing to both the appeal and success of their learning experiences.

1. The Appeal of Interactivity.

When commenting on the appeal of the videodisc, many students talked in general about their participation with the videodisc.

> "You could participate more. Like, if you were in school, you wouldn't have as big a chance of getting called on."
>
> "I like doing, not listening."
>
> "I liked how they would give you information and you could do something with it."

Interestingly, some of the students' negative comments regarding the appeal of the disc also focused on the issue of participation; students appeared to find fault when their participation was too limited. One student commented, "You didn't do much. You just sat there listening or touched the screen once or twice." Three students who used the videodisc with the class

commented on their inability to direct the navigational options This made them feel that they were not participating as directly as they would have liked in the lessons.

"The class wanted to replay things I didn't."

"You didn't do much, you just sat there."

These comments seem to indicate that students recognized and appreciated the unique interactive capabilities of the videodisc and were frustrated when unable to exploit them to their fullest advantage. When their interaction with the disc was limited, students found the disc less appealing, pointing to the importance of this quality as a factor in the disc's appeal.

When asked to make comparisons to other educational media, such as television and/or movies (n=41), student comments often focused on the relative levels of participation afforded by each The videodisc's greater capacity for participation and interaction was credited by many with enhancing the learning experience. Over two-thirds of the students (71%) said that videodisc learning was more participatory; using the disc required interaction. They talked about how this interaction encouraged them to pay attention, helped them learn more, and made using the videodisc fun.

> "It's more interesting because we get to do it. In television or movies, we just watch--it's not like we can participate in it. But, in this [the videodisc], we do the decisions and I think it makes us more interested in it than just sitting down and looking at the screen."
>
> "[With] this, you get to touch the screen and it's interesting and fun."

In elaborating on the interactive and participatory nature of the videodisc, student comments often focused more specifically on issues of control. Students appeared quite astute in identifying this issue as a relevant factor when describing the uniqueness of their experiences with the disc. Having increased control over

their own learning experiences was seen as a positive aspect of working with the videodisc and indeed, when they could not get the system to respond effectively, students were frustrated or disappointed. Students seemed able to identify the high level of control afforded by the disc as an important factor contributing to an educational experience that was self-paced and non-punitive in nature and in which learning was motivated by self-interest

Several of the videodisc's interactive options were cited by students as features which contributed to their ability to control their experience. The touchscreen, for example, received many enthusiastic comments and was identified by some students as an important feature related to control of the system. A few students compared it directly to more common and less convenient methods of user input.

> "I liked the screen, how you can touch it and just go ahead."

> "You don't have to fiddle with the keyboard if you're not a very good typer. You just touch the screen "

When the touchscreen did not react to their touch or respond as expected, students appeared frustrated.

> "Sometimes it was confusing. If you touched the wrong place or with two fingers, and went somewhere wrong, you had to get back to the next place."

> "I didn't like it when the machine wouldn't obey."

Students cited other interactive options, such as the ability to replay, pause, answer questions, and make choices as instrumental in creating a rich learning experience. Students said that using the interactive features increased their participation in the lessons and, more importantly, their ability to tailor the learning process to their own needs. They could proceed at their own pace and replay or pause when they wished.

"I liked it because you could touch the screen You could pause when you wanted to You could replay it if you didn't catch the whole thing Sometimes in school, you don't get called on. Here, you have to do something, or it won't go on It has a nice learning ability "

"I liked the ability to review what I learned if I was unsure of something."

Students' concern with this ability to pace their own learning experience was further emphasized in their discussions comparing the videodisc to other educational media. When comparing the videodisc to television and movies (n=41), over two-thirds of the students discussed the more interactive nature of the videodisc Three-fourths of these students specifically mentioned interactive aspects of the disc such as pausing, answering questions, and making choices. More than a third talked about replaying selected portions of the video. As students observed, such capabilities are directly related to students ability to set their own learning pace.

"On a videodisc, it's easy if you don't know the question or the answer. You can go back and check. In TV, you see it once and then you don't know where it went."

"With a videodisc, you can watch at your pace. If you don't understand something, you can go back and review But with TV, it just keeps going. You can't press Pause, too bad, you just miss it."

When comparing the videodisc to books (n=34), nearly one-third of the students mentioned similarities between the two media related to their ability to enjoy a self-paced learning experience Students talked about being able to go back and review desired sections, to choose what to do, and to stop and reflect on what they are finding out.

"In a book and the videodisc, you can go back to different parts if you didn't understand it If you want to find out something again, you can go back and read or watch it again "

"You can just stop and think about things and continue, or go back to the beginning if you didn't understand something."

"I think it's the same because you can go over it and it tells you when you're wrong and then you can go back and find out why. It's set up the same, like a textbook."

In addition, students found the traditional classroom setting less conducive than a videodisc to fostering a learning situation geared to their own, individual pace. Students enjoyed the ability, allowed by the videodisc, to go as slowly or quickly as they needed in order to understand the information and replay sections for clarification.

"In a classroom, the teacher explains what you do and you have to do it and work on a level with all the other kids. Sometimes it's a problem because you already know things or you are too far behind. If someone wants to stop the teacher, you can't because you have to stop the whole class."

"[The videodisc] is better because you get to do it individually and you don't have to wait around while other people ask questions. It's just you and the computer."

Some students also perceived the videodisc as offering an educational experience that was non-punitive in nature, especially when making comparisons to a traditional classroom setting. These students cited the replay option as a way to ask questions of the disc without embarrassing themselves or interrupting the teacher's presentation.

"It's easier [with the videodisc] because the teacher doesn't like reviewing things over and over. He doesn't like saying it so many times."

"In a class, it's hard sometimes to get something you missed. You have to stay after school. [The videodisc] you just turn on."

"When I'm in a classroom and the teacher asks a question, I feel self-conscious about being wrong. With the [videodisc] I don't have to say nothing, just press buttons."

While it seems clear that students were aware and quite appreciative of the participation and control afforded them by videodisc use, we were also interested in how students managed such control. Therefore, we asked them questions concerning the ease with which they were able to navigate system use and about which interactive options they utilized and for what purposes Their responses helped us gain a better understanding of the impact of user control and participation on users' educational experiences

2 Ease of Videodisc System Use

For the most part, users were able to navigate successfully through the course and recover from problems on their own When students or teachers had questions, observers usually asked them to try to solve the problems themselves and most often they did

We assessed the students' and teachers' comfort with the system by the frequency of their questions to the observers or to another student and their use of interactive options. We also evaluated their comfort by other outward signs, such as hesitation to touch the screen. Two-thirds of the individuals and pairs of students seemed comfortable with the system overall, and one-third showed some tentativeness. No one seemed uncomfortable using the system.

After using the videodisc system, individuals and pairs of students (n=30) were asked how easy or hard it was for them to use the system (see Table 1). Here we found that students made no distinction between the system hardware and our disc The vast majority of students (93%) found the system 'easy' or 'pretty easy' to use, citing at most one or two instances of difficulty; only two students said the system was 'difficult' to use. A few students found the system unqualifiably very easy to use, offering such comments as, "It gave you as much time as you needed and when you were ready you could just move on," and "It just took a minute

of thinking." The students who cited problems focused on difficulties with understanding directions for specific lessons, rather than with operating the system. For example, some students mentioned the directions in the various chart-making activities and the plant experiments as difficult to understand. Directions for the game "Baffles" were also cited as difficult. One student, however, did point to a difficulty in operating the system, she was trying to pause video sequences at a particular frame, which is nearly impossible to do with our system.

Table 1

Student descriptions regarding ease of system use

(n=30)

	Total #	/male	female/	/indiv	pair/
Easy-	15	10	5	8	7
Pretty Easy-	13	4	9	4	9
Difficult-	2	1	1	1	1
	30	15	15	13	17

When students who used the videodisc system with their class were asked whether they thought it would be easy or hard to use the system by themselves (n=13), they were nearly evenly divided into the two categories (53%-hard, 46%-easy) (see Table 2). An apparent gender difference should be noted, with boys tending to feel the system would be easy to use and girls tending to feel it would be hard. Those who felt that the system would be easy to use, however, often qualified this judgment by adding that they would

need some experience and/or instructions. "Once you had instructions and knew what to do on your own [it would be easy]."

Students who felt that the system would be hard to use either offered no further explanation or seemed to focus on the need for someone else to explain things: "(It would be harder to use) because the teacher wouldn't be there to explain it more thoroughly." Lack of familiarity was also cited in explanation for the system being hard to use: "(It would probably be) hard because we never used it before."

Table 2

Classroom student descriptions regarding ease of system use

(n=13)

	Total #	/male	female/
Easy-	6	5	1
Hard-	7	1	6
	13	6	7

Classroom students who were not interviewed filled out questionnaires (n=73) which included the question, "Do you think it would be easy or hard to use the system by yourself?" A majority of these students (88%) indicated that they thought the system would be easy to use, while a few (12%) felt that it might be hard

3. Use of Interactive Options

Although students interacted with the system every time they touched the screen, we wanted to examine their use of what we termed interactive options--features used to do something other than simply continue forward in the simplest, most direct path through the lesson. For example, touching Go Ahead or Menu at the end of a certain section, or Experiments to continue during a lesson were not counted as using interactive options Interactive options included: Pause, Replay, Redo, Review, Backward, Forward, Charts, Notes, and Examples. We also considered students' interruption of playing video or audio by pressing Go Ahead as use of an interactive option. It should be noted that researchers' directions affected students' use of interactive options in two areas: students were asked to view the main sections within the lessons in order, and to view the Thoughts section of "Pauling" to be sure they could follow the organization of lesson concepts presented. Thoughts, therefore, is not counted as an interactive option. To understand how these options influenced students' experiences with the videodisc, we explored both how often the options were utilized and what factors motivated their use

A wide range of interactive option use existed among users. On rare occasions some users did not use any interactive options Generally, however, interactive option use ranged between two and 43 times per lesson, with an average of six times per lesson. Some use mode and lesson differences were found and are reported in Section D, The Appropriateness of Particular Use Modes.

The option used most commonly was to see something again (including touching the action box Replay, Redo, or Review, and choosing Menu and then reselecting the same item). This type of option was utilized by all but one of the users. One pair of students even used the Backward and Forward action boxes as a rewind feature to return to a certain spot and replay Pause was

also utilized by a majority of the users In addition, Chart was used by most of the users who participated in lessons with this option. Notes and Examples were also utilized, although less frequently than the previously mentioned options. The action box labeled ???, which presents students with discussion questions, was rarely touched.

Interactive options were used most frequently when students needed help filling out the worksheets. For example, Replay and Pause were used most often in this manner, with Chart, Notes, and the action box labeled ??? also used at times for the same reason On occasion, curiosity also catalyzed the use of interactive cptions. Students would sometimes press Chart just to see if it displayed the same chart as the paper they were handed. Notes and the action box labeled ??? were also touched on several occasions out of curiosity.

A few students used the interactive features to review appealing visuals. For example, two students replayed a section of "Edgerton" just because they wanted to see it again: one of them replayed the high speed footage of someone smashing a Coke bottle with a hammer, saying, "Wait, I want to go back again. (REPLAY) Ta da! Watch this--thousands of pieces." One teacher replayed a video clip of a molding orange to tease his students, who thought it looked disgusting.

What follows are three examples of ways in which students from the pair use mode used the interactive options, and the discussion that accompanied their use. The first example shows students using an interactive option--Replay--to help them understand what was presented in the lesson. This pair replayed a clip in "Animal Disguises" about three fish--the wrasse, the blenny and the tang At the end of the clip, the following question appears on the screen: "Is any animal disguised in a new way?" If so, students are supposed to add a category onto their charts. The two students in this example were unsure of the answer, so they replayed the

clip While they viewed it, they tried to identify the three fish as they came in and out of view on the screen

A: (Looks at B for answer to question. "Is any animal disguised in a new way?")
B: I don't know.
A: Which one was that little one?
B: I don't know. I think a wrasse.
A: Should we replay? (REPLAY)
B: Which one is the wrasse?
A: (Points to a fish on the screen.)
B: (Points to another fish on the screen.) The yellow thing is a tang. That's a blenny. This is the tang
A: That's a blenny.
B: I guess that's the wrasse
A: No, that's the wrasse.
B: No, a blenny, because it looks like a wrasse and has sharp jaws.
A: That's a tang.
B: I know!
A: The blenny looks like a wrasse, but doesn't do everything like a wrasse.
(They write on their charts)

The second example demonstrates the use of an interactive option because one girl was particularly impressed by several passages showing a milk drop falling in slow motion in the "Milk and Water Drops" section of "Edgerton." She replayed these passages for her partner. For some time, she tried to return to one particular place in the section, until her partner reminded her that the drop appeared again later. Primarily as a result of these attempts, this pair used the highest number of interactive features in one lesson--43. (In contrast, they did not use even one interactive option during "Pauling," the second lesson they completed.)

C: Cool!
D: Cool. Did you see that? Oh, I like that (laughs) (PAUSE) Look at how they come out little crowns. Look how the bubbles go out. That's cool!
C: (GO AHEAD)
D: (PAUSE) Look how that's coming. It's cool! (GO AHEAD)
C. Ooh!

D Look at how See that! Look how that doesn't splatter out
C Yeah

The final example demonstrates the use of an interactive option catalyzed by curiosity about a Notes action box Touching this box brings students to a screen which displays thought questions. Here, it is interesting to note how reading the screen triggered the students' use of Replay for additional help in filling out their charts

F What happens if we press Notes? (NOTES)
E. (after reading screen) Oh. we're supposed to write things like that?
F. Well, the predator is the praying mantis, isn't it? The praying mantis eats all those huge things.
E. Oh, wait. We can do Replay (REPLAY) Oh The praying mantis is the predator So, do you want to write that down?

4. Summary

Results indicate that students, for the most part, found the videodisc system appealing and easy to use. Any problems experienced by users seemed minor and resulted from less than clear directions within the lessons. Interestingly, even those students from the classroom who hypothesized that the system might prove difficult to use alone, indicated that when provided with an introduction and ongoing support it would be easy to use Therefore, we believe that students would have little difficulty using the system.

The results regarding interactive option use indicate that users took advantage of a variety of the disc's interactive capabilities. In general options were used most often as a means for better understanding or completing the lessons The ability to either pause or review a particular segment was exploited most often by students While these kinds of options were sometimes used to review enjoyable sections of the video, they more often provided

students with assistance in reaching an understanding of the material being presented. For example, students often paused the lesson so that they could take notes or discuss the material

Our findings regarding the importance of interactivity and user control strongly support assumptions about the positive impact of the videodisc's interactive nature. Students proved to be extremely enthusiastic in their comments about the control and participation afforded them by the disc. They said increased involvement contributed to both the appeal and success of their learning experience.

Contrary to assumptions maintaining that user control might detract from the effectiveness of a lesson, students did not appear to have any significant difficulty in managing the increased responsibility required by the active learning process. They successfully navigated through the lessons and exploited a variety of interactive options for their own varied purposes. Clearly students enjoyed and were able to take advantage of an educational experience in which they were active participants, taking control of and responsibility for their own learning.

B. The Importance of High Quality Visuals

Student comments describing the disc often characterized the the visual presentations as both unique and compelling. The visuals appeared to provoke and maintain students' interest in the lessons, they were in fact cited by several students as the most appealing aspect of the videodisc. In addition, 60% of the students from the classroom mode who filled out questionnaires (n=73) rated watching the video segments of the disc as a feature they liked very much. Comments regarding the visuals of the videodisc occurred most often when students were comparing the system to other media, such as books and television. Students found the videodisc visuals to provide more realistic and interesting portrayals of information that helped their understanding of the lesson content.

Some students focused on the appeal of visual presentations in an educational experience. Apparently, videodisc use, with its attendant high quality visuals, proved more interesting and fun than more traditional educational experiences for some students.

> "It had visual effects, so it was more fun than reading and lecture."
>
> "[The videodisc] is a mixture of computer animation and movies so it is more interesting."
>
> "Learning from a book on these subjects can get kind of boring. And it's really a lot harder to do these experiments from a book than just watching them."

Part of the appeal of the visuals seemed to lie in their ability to present students with realistic representations of the material being studied. This was especially apparent in students' discussions of the "Animal Disguises" lesson. Students perceived this ability as a distinct advantage.

"I liked the way they showed animals the way they are--they move--not like in a book, where they stay put."

"You don't have to read it out of a book You see it in its habitat the way it eally is. It's on a screen. Usually we just talk about it, you don't see it."

"In the class...the teacher would be talking about it. With the videodisc, you see how it really happened. You get to see it instead of hearing it talked about."

"It shows real piotures. A computer doesn't do that..."

As described by the students, such realistic images appeared to help students reach a clear understanding of the material presented.

"You can see what's happening instead of trying to imagine "

"[With the videodisc] you can visualize everything. In a book, they just tell you about it and you have to picture it for yourself. If everybody reads the same book about a house, everyone has a different picture of the house."

"You can have pictures in a book, but this was moving pictures. Books couldn't show how [a plant] moved, they could only show it when it was bent out. Here it showed it actually moving."

Students' comments regarding the presentations in the "Edgerton" lesson illustrate their new-found understanding as a result of the visuals.

"I didn't know that when liquid drops, it forms a crown. When it falls into more water, it forms a sphere."

"I thought [a cat's] tongue would go forward, but it es backward."

When visual presentations were unclear, as in the case of certain "Plants and Light" segments, students' ability to understand lesson content was impaired. Such evidence underscores the importance of high quality visual images and suggests there may

be a relationship between visual presentations and understanding.

Finally, classroom students who filled out questionnaires (n=73) were asked to comparatively assess the two lessons they worked on. Interestingly, they tended to prefer the "Animal Disguises" lesson to "Plants and Light," and the "Edgerton" lesson to "Pauling. The two lessons of preference contained more intriguing visual presentations, which might account for these findings.

Clearly, students were quite engaged by the visual presentations of the videodisc. As much of the literature has suggested, the videodisc's ability to provide realistic, high quality images was indeed viewed by students as a unique and positive capability of the technology, which contributed to a rich and enjoyable educational experience.

C. The Potential of Videodisc as a Teaching Tool for Inquiry Learning

Students were carefully observed during disc use and lesson interviews were conducted with students to explore their experiences with SEEING THE UNSEEN lessons. We wanted to know if students acquired basic lesson content and if they practiced any scientific methods in the process. By lesson content we mean the main ideas presented in each lesson: the concepts, information, and vocabulary. By methods we mean such techniques as gathering and organizing data, formulating hypotheses, making models, inferences, and predictions, and applying new information to analagous problems.

Our results are reported in two sections: 1) Student Comprehension of Lesson Content and 2) Student Engagement in Scientific Methods. Through an exploration of these issues we hoped to gain a better understanding of the potential of videodisc technology for engaging students in an inquiry approach to learning.

1. Student Comprehension of Lesson Content.

In this section, we will explore students' understanding of the specific lesson content presented in the lessons. Here, we were interested in whether students were able to comprehend the basic information, concepts, and vocabulary illustrated in each of the four lessons.

a. "How Does Light Affect Plants?"

Most students could describe the three experiments on plants and light and had a general idea about the ways in which light affects plants. In describing the lesson, students talked mostly

about lesson content, rather than the concept of the experimental design. When asked what the lesson was about and what they had learned (n=24), all students talked about the subject matter--plants and light. More than half of the students (57%) offered a response which included both a general statement and a specific example. "We did experiments on different colors of light and where the light was." One-third made a general statement: "It was about how light affects plants", and two students mentioned a specific example from the lesson: "I didn't know that plants nodded toward the sun." No student mentioned the experimental design (e.g., no one said the lesson was about how to study plants and light).

To see how students were engaged by the content of the lesson, they were asked questions about each experiment. Here again, students talked mainly about the effect of the experiments (what happened and why). Students usually discussed the first experiment in terms of plant movement in relation to the position of the sun. Almost half of the students (43%) mentioned the response of plants to one sun position, such as overhead.

When asked to describe the second experiment, students said it was about plants and colors of light. More than one-third of the students (39%) responded by making a general statement about the movement of plants in different colors of light. One-quarter of the students (26%) made specific statements about the effect of red, green, or blue light on plants. A few students (17%) compared sunlight (containing all colors) to the different colors (red, blue, green). Some students elaborated on their responses by talking about why plants reacted differently to different colors of light. Those that did not remember the lesson's explanations offered their own. Other students (17%) said they could not follow the experiment.

When asked to describe the third experiment, most students said it was about the part of the plant that responds to light

One-third of the students noted that the experiment involved "tips" and went on to describe one part of the experiment.

> "When the tip is cut, then it just stays there When the tip is covered, it just stays there In both of those the control bends toward the light. When the stems are covered they both bend toward the light."

Some students had trouble with one or more of the experiments because the visuals were unclear. In one experiment, different plants' reactions to different colored light was too similar to be accurately interpreted by the students. In a second experiment, computer overlays covering various parts of the plant were confusing. For a few, this obscured the intent of the lessons, others, however, were still able to derive its meaning

> "I was confused because I couldn't really tell, for example with the red light because it was so slight--the movement. And the green, I thought was moving a lot but the computer said it didn't respond to it. I thought it was moving--like bending away but they said it didn't respond to it. I was surprised."

> "The experiment was to see which part of the plant controlled how it responded. We found out the tip controls."

> "We covered the stem and the tip and saw the tip did it. At first it was confusing because it put the red box on the tip and then we figured out that it covered the tip "

For the most part, students who participated in this lesson talked about its content in ways that indicated some level of understanding. Some of the difficulties experienced by students seem to be attributable to unclear visual presentations

b. "What Disguises Do Animals Use?"

The "Animal Disguises" lesson contains a series of video clips that illustrate various ways in which animals disguise themselves Students were especially intrigued with the subject of animal disguises and every student questioned (n=20) talked about this aspect of the lesson Students were also captivated by the wide range of animals presented in the lesson. In discussing the subject of animal disguises, one-quarter of the students mentioned details about the disguises of particular animals or offered general observations.

> "A lot of animals are almost invisible--]' poisonous, invisible, or look alikes."

> "A lot of animals hid in the background or warned off other animals."

> "Animals that look harmless may be harmful. Lotsa animals I didn't know that blend with other things."

> "I thought most animals in disguise camouflage themselves, I didn't know they imitated each other."

Some students talked about why the animals have disguises, such as for hiding, for catching prey or food, or to survive.

> "Some animals can trick other animals into thinking that they aren't what they look like--they take advantage of that."

> "I learned ways animals try to eat and try to get their food "

Most students commented on animals or animal behaviors they had never seen before. Simply finding out about a new animal proved interesting to many students.

> "There are many different animals in the sea I've never seen an alligator snapping turtle."

> "I learned about all these different animals "

"I learned a lot about bugs and fish and stuff. I didn't know what a walking stick was, or a tang and that snake I didn't know about blue jays eating moths, I thought they just ate worms like other birds."

"I didn't really know there were so many animals that could be camouflaged. I didn't know there was a turtle underground who was so camouflaged he could open his mouth and he had a strange tongue. I didn't know all the facts--I learned a lot of things like how the blue jay ate moths and about those two butterflies. I knew about the praying mantis, but not about the walking stick."

Students who participated in this lesson displayed a clear interest in and understanding of the material presented. They comprehended the concept of animal disguises, discussing in detail both how and why animals disguise themselves. Students also displayed considerable interest in learning about animals which were unfamiliar.

c. "What Happens When Time Is Altered?"

When discussing the "Edgerton" lesson, students showed a great ability to recall high-speed and time-lapse photograghy images. In addition, they were able to talk about how altering the speed of motion might change what can be perceived. When asked what the lesson was about and what they learned (n=19), more than half the students (58%) talked about specific informational or visual content, such as milk and water drops, the stroboscope, or Dr. Edgerton. Nearly all students (94%) described the lesson by noting the general underlying concept of the lesson: the effect and/or reason for altering the speed of an event. Students' comments included:

"The way that things looked speeded up or slowed down "

"Not showing things at their natural pace."

"How you can learn better about different things if you slowed them down or speeded them up."

"How you can see with the aided eye some things you can't see with the unaided eye."

Many students (n=17) were able to successfully explain or define high-speed (88%) and time-lapse (76%) techniques Students' comments about high-speed included:

"If you take something that moves fast and then you slow it down."

"You can see mostly every move it makes "

Student comments about time-lapse included:

"When you speed something up to learn about it.. starfish moving, watching things grow."

"For something very slow. You take pictures of it only once every so often, so instead of watching a plant growing for ten hours, you can see it in a few seconds."

The remaining students (25%) distinguished high-speed from time-lapse but reversed the definitions.

Perhaps more than the other lessons on the videodisc, this lesson offered students a linguistic challenge. In several cases, students who correctly defined the two techniques appeared to have difficulty distinguishing between the name and the effect of the technique. This became apparent during the lesson activity in which students viewed fourteen video clips and identified on a chart which clips were made using high-speed and which were made using time-lapse techniques. Some students avoided confusion by changing the names on their charts, relabeling high-speed as, "slow down" or "slow" and time-lapse as "speeded up" or "fast " In addition to the time-lapse and high-speed terminology, students were introduced to the stroboscope. Students understood what the machine did, but some talked about it as "the strobe thing," or "the psychometer, ' or "the streptoscope."

Students who participated in this lesson demonstrated a high

degree of interest and a fairly solid understanding of the subject matter presented. A majority were able to successfully define the two forms of photography illustrated in the lesson and displayed an understanding of the purpose in altering the perceived speed of an event.

d. "How Do Scientists Study Things They Can't See?"

Students were especially engaged watching how Pauling went about figuring out the shape of a three-dimensional block hidden inside a small covered box. When asked what the lesson was about and what they had learned (n=18), almost all students (89%) talked about the task of finding out the shape of the block in the box.

> "How you could tell how long the sides were by turning the box one way it would roll--then the other way it would slide. Then you could find out there was a side. Then how quickly it would roll would tell you how long or how short the sides were--so you could figure out how many sides there were in all."

> "The guy Pauling--he tried to figure out what was in the box. By the way he turned it, he could figure out if it was round or if it has bumps on it."

> "Showing different ways of figuring out something in a box without looking, what shape, what the object is."

Many students (77%) made specific references to the steps that Pauling took in order to solve the problem.

> "He rolled the box back and forth, side to side, and tried to find out some clues by listening to the movement."

> "He tilted [the box] in all directions. Seeing how it rolled, if it slid, stuff like that."

More than half of the students also discussed the lesson in more general terms, explaining how the lesson concerned finding out about about things you cannot see

"About how you can tell what something is without seeing it [The lesson] showed you different tasks you could do to figure something out."

"About identifying things without seeing them--with your other senses."

"How you could figure out what something is if you couldn't see it."

"If I ever had to figure out something I couldn't see or touch, I'd know some things to help me figure it out. "

The majority of students who participated in this lesson were able to discuss and understand the specific informational content of the lesson, often providing specific descriptions of Pauling's testing process.

2. Student Engagement in Scientific Methods.

Each of the four lessons was designed to engage students in different inquiry-oriented, scientific exploration techniques. "Plants and Light" engages students in observing and recording data from controlled experiments and making predictions based on their observations. "Animal Disguises" engages students in making careful observations, abstracting patterns and forming categories, and recording and organizing their information on charts "Edgerton" engages students in making observations and recognizing patterns. "Pauling" engages students in forming hypotheses, conducting investigations, making predictions, and drawing conclusions. Following is a discussion concerning the extent to which students were engaged in and applied these techniques in the lessons.

a. "How Does Light Affect Plants?"

Most students understood the meaning of the experimental design employed in this lesson, including the control of independent and dependent variables and the use of experimental and control groups. They observed how light affects plants and recorded their observations on their charts. Some students, however, had problems with the lesson. A few missed or misunderstood the reasons for the experimental design and were confused about the experimental and control groups. Others had trouble recording their data on a chart and making predictions based on recorded data.

When asked why two shoots were used in the experiments, almost two-thirds of the students (61%) were able to explain that the second shoot, "the control," was there for comparison--"the before and the after," "to see what it should have done," "one that was normal." Others (17%) were uncertain about the purpose of the control. One-fifth of the students (22%) said they did not understand the experiment.

Most students were able to make predictions regarding "what if" situations based on their observations and many could describe an analagous experiment to study the effect of water on plants.

Several times during the lesson, students responded to "what if" questions which asked them to draw conclusions from experimental data. When asked how they figured out the answers, almost half of the students (48%) reported that they used the charts on which they had recorded their observations a almost half (48%) said they remembered from the videodisc lesson. Only a few said they guessed. One student emphasized that answering the questions took organization: "I put together all that I learned there and I tried to figure it out. I organized all my thoughts and went over what I learned and then I was able to put all the categories together easier."

When asked about an analogous problem--how they would study

the effect of water on plants--over three-quarters of the students (78%) made up an experimental study, indicating their ability to apply the approach demonstrated by the lesson. Many of the specifics mentioned in their experiments paralleled the experiments that they had observed including the use of controls, limiting variables, and making observations over time.

> "I'd go to watch to see what the water does in the morning, what it does in the afternoon, and what it does at night."
>
> "Try putting different amounts on different plants and see how they react. Give them equal heat and equal light."
>
> "You could do it the same way as this (the lesson). Put one in water and one not in water or put half in water and half not in water. First put top in water and bottom not, then switch around and see what happened. Then different light shining on the water and different colors of water and different kinds--one in salt and one in mineral and see which kind is best for the plant--which one grew the most."

Only a few students were unsure how they might conduct an experiment: two said that they would ask an adult such as a gardener, mother or teacher, for advice.

The students who participated in this lesson appeared to understand the experimental design to varying degrees, but a majority proved able to utilize the information presented and techniques encouraged by the lesson to answer questions throughout the lesson. In addition, many of the students demonstrated an ability to apply the concepts presented in the lesson to an analogous problem.

b. "What Disguises Do Animals Use?"

In this lesson, students were involved in making detailed observations, forming categories by organizing information in charts and, when time permitted, testing those categories.

By analyzing the charts students filled out during the lesson

(n=24), we discoverd most students (67%) classified the animal video clips into disguise categories. (Three of these students received some prompting from the observer.) Two students (13%) classified the animals according to the Notes questions which were both presented on the videodisc and handed out as accompanying material. Five students (21%) demonstrated an inablility to organize the information from the videodisc into categories based on disguises.

Of those students who classified the clips based on the disguises illustrated, there was a great range in the number of categories formed (two-eight). Almost one-half of the students (47%) formed two or three categories a requested in the lesson directions; one-third (32%) formed four or five categories, and the remaining students (21%) formed seven or eight categories.

There is also a great range in the kinds of categories formed. All students who classified included at least two categories that had been generalized from specific cases--for example, "acts like another animal" and "a certain color that doesn't change so it can blend in or contrast." However, many students had additional categories that were not discrete, parallel, or analogous units--they were exclusive not inclusive For example, the category "green, plant-like looking" was formed specifically for the walking stick and "one is a real butterfly and one is poisonous" was formed for only the case of the monarch and viceroy.

One explanation for this kind of exclusive categorization may be that most students (71%) did not have the chance to view the second set of clips, which were designed to help students test the categories derived from the first set. Two pairs of students who did view clips from the second set seemed to find these additional clips helpful in forming more discrete categories. For example, one pair of students began with the category, "like another fish and acts like another fish." Later, after viewing a clip in the

second set, they crossed out the word fish and put animal. In the interview, one of the students explained, "I came across a second pair of animals who weren't fish and I wanted to generalize it more so it could fit more things."

When students (n=23) were asked about the usefulness of categorizing (Why do you think we had you make categories?), a majority (70%) said categories provide a way to organize and easily locate things.

> "If you're collecting a lot of things that are similar, its easier to categorize, if wanted to pick one out, you could find it."
>
> "So it would be more organized. And like you have titles and specific columns instead of just writing it down. It's to get a picture of what it looks like, of what the categories are."
>
> "When I categorized the animals it dawned on me that there were so many more ways I could categorize things, like before, when I thought about categorizing stuff, I thought mainly about color, shape, size--but there are a lot of different ways you can categorize things."

In reference to the lesson, students said categories allowed them to see patterns of similarities and differences among animals and their disguises.

> "So we can find out patterns in the disguises "
>
> "Helps you take a closer look at what they have in common "

When students were asked to solve an analogous problem (how they would organize information about what food the animals in their neighborhood eat), slightly more than half (52%) replied they would group the information in categories, others (29%) did not create categories.

The students creating categories (n=21) did so in patterns similar to those used for the animal disguises

"I'd put all the food I saw into columns and then I'd write the animals that eat it."

"Just organize them by what they eat. Things that ate grass are one category. Things that ate plants Things that ate animals, and things that eat small and big animals "

Rather than creating categories, almost one-third of the students (29%) indicated that they would create a catalogue listing each animal and beside it, items in its diet, with a one-to-one correspondence between specific animals and their diet items.

"I'd first of all take, let's say, the squirrel. Eats mostly acorns, nuts, and whatever else. First have to find what animals in my neighborhood--I saw a rabbit, a rabbit eats carrots. I'd make different paragraphs. At the end, I'd say this is what all the animals in my neighborhood eat. Of course I'd have to look up in an encyclopedia what they eat "

"I would write different food across the top and animals on the side and make a chart and join the point where they match. For example, sunflower seed on top and some kind of bird on left, and where they meet put a check."

Three students (14%) had no consistent organizing principle. One student didn't know how to respond to the question. With one exception, all of the students used food as their organizing factor, one student used animals as the organizing factor for this task.

The majority of students who participated in this lesson were able to successfully employ a variety of scientific exploration techniques as they completed the lesson. In addition, they seemed to understand the nature and purpose of these techniques, with many students able to apply them to an analogous problem

c. "What Happens When Time Is Altered?"

In this lesson students are encouraged to participate in an open-ended exploration of the nature of altered perceptions of time. The lesson was designed to generate thought and discussion

about differences in perception and hypotheses about normally undiscernable events.

When students were asked why someone would want to study something using high-speed or time-lapse techniques (n=17), all of the students responded that the techniques enable one to discover more about an event or changing object.

> "If they wanted to find out more about an object they weren't aware of before. Make a new discovery of how something works Be aware."

> "With time-lapse, if you want to watch how a plant grows it makes it easier instead of sitting in front of a plant for two years. With high-speed, if you want to find out how certain materials react, about how something reacts to other things that happen too fast for us to see."

When asked to describe something that happens too fast to be seen (n=21) (e.g., something that could be studied using high-speed techniques), all but two students named appropriate kinds of events. Almost half of the students (42%) responded with an example from the videodisc and an original example not from the videodisc; almost half (42%) chose examples only from the disc, and slightly less than one-quarter (21%) chose only examples that were not from the videodisc. For example, students responded with events from the videodisc such as milk and water dripping, popcorn popping, and a hummingbird flying. Original examples not from the videodisc included rain falling, a meteor falling, a bee flying, and molecules moving. Inappropriate events were either slow actions, such as a spider weaving a web or an invisible action, such as radio waves.

When asked to describe an event that happens too slow to be seen (n=21)--e.g., one that could be studied using time-lapse techniques--the students displayed remarkable recall of the videoclips. Most students (76%) mentioned two examples from the disc, including a plant growing, a spider weaving a web, an orange molding, and the way clouds form. Three students mentioned an

example from the disc and one original example--an egg hatching, the seasons changing, and the movement of a clock's hour hand Five students named actions appropriate only to high-speed techniques; two students could not think of anything

Students were asked to pick one of their examples, explain how they could study it and what they would see that they couldn't see before. Nearly all students said that one can see more when using either high-speed or time-lapse techniques to look at phenomena.

> "I want to observe how water falls, when if forms shapes and craters of different sizes. When drops bounce, I want to see how far they bounce off, and the motion of water running fast and slow."

> "You could see change. Before the grass would all look the same because it grows so slowly "

> "You could see a body grow if you had a camera on all the time."

Students participating in this lesson clearly understood the purpose and application of exploring altered perceptions of time, as demonstrated through their analyses and discussions of videodisc and self-generated examples.

d. "How Do Scientists Study Things They Can't See?"

Most students were engaged in the inquiry techniques of forming hypotheses, conducting investigations, making predictions, and drawing conclusions.

While many students talked about the specific subject of finding out the shape of the block in the box, when asked what the lesson was about (n=18), more than a third said it was about finding information in scientific ways, such as by making hypotheses or observations.

> "About making hypotheses and what you find and seeing if you are correct by going over information you know "

"About observation--like if you do something and something happens--you can make a conclusion about it."

"If I had something in a box and had no idea what it was If I thought, made hypotheses, I could find out. If I made conclusions like in 'Baffles,' I could find out where and what was hidden without seeing--just by using my brain."

We asked students what steps Pauling took to figure out what was in the box. As previously noted, almost all of the students (77%) gave a step by step description of what he did, including at least two steps. However, some of these students (36%) added that he made hypotheses or used the information he found to reach a conclusion: "He took hypotheses about what was inside the box He did this by listening to it and moving the box around."

All of the students except one talked about the idea of hypothesis testing as presented in this lesson. When asked if Pauling's way of solving the problem was guessing or not, all students but one felt that Pauling was not guessing and they often went on to describe some sort of plan.

"It's a hypothesis. He's guessing on facts he can figure out It's not just a wild guess."

"It's not that much like guessing. He knew what to do. He is a scientist so he knew what to do better than another. He won a Nobel prize, he probably studied that kind of thing "

"It's hypothesizing It's an educated guess. After you make a couple of them you put them all together and realize what's in the box."

Students were able to apply Pauling's reasoning process, to some extent, in an analogous problem posed by the "Baffles" game When asked about how their work with the game was similar to Pauling's work with the box (n=17), almost three-quarters of the students (71%) responded that there was some similarity in the way they thought about playing the game and the way that Pauling

thought about what was in the box

> "It's kind of the same because you couldn't see where the baffles were so you had to make an educated guess to see where the laser bounced off."
>
> "The same because you can do something to it [baffle board] to see something happen, then make inferences about what you could see or hear about what happened."

While the method of reasoning was considered to be the same, more than one-quarter of the students (29%) said that the practical method was different and three students (10%) said the problem was different.

> "I didn't have the box to feel or shake. I had to work by pressing numbers to find out where baffles were "
>
> "You have to figure out something you can't see or touch but you can't hold it and roll it up and down to see where it is--can't do anything with it."
>
> "It was the same because you had to try to find out where they were and make hypotheses. It was different because you knew what they were."

Only two students said that working with the box was entirely different from their work with the "Baffles" game.

> "Dr. Pauling knew more than us. He knew his information better than we did."
>
> "In 'Baffles' you had a better chance than just shaking it "
>
> "The lasers gave you a big clue as to where it was "

Students participating in this lesson were engaged by the exploration techniques illustrated and for the most part, proved able to recognize and apply the process of hypothesis testing in their work with the "Baffles" game

3 Summary

Our findings in this section indicate that students were generally able to understand the material presented in each of the four lessons. Students could discuss the informational content of the lessons, often employing new vocabulary specific to the lessons. Students also practiced scientific methods with variable success.

In light of the results of this section, it appears that videodisc technology is indeed capable of providing students with an educational experience in which they can successfully acquire information through an exploratory, inquiry-oriented process. In addition, students displayed an ability to further apply the information and techniques encouraged in the lessons to analogous situations and problems.

Interestingly, we found that students' willingness to utilize the interactive options and carefully review material to their satisfaction tended to cause the lesson sessions to run longer than anticipated. In several cases students were not able to complete an entire lesson in the time alotted (30-40 minutes) This occurred most often during the "Animal Disguises" lesson. Students' engagement in lesson content and process indicates that exploratory activities can lend themselves to use on more than one occasion.

It is important to note here that SEEING THE UNSEEN was not intended to be used as an independent, instrument of study Rather, it was intended for use as a supplementary tool, to be incorporated into a wider context of instruction. Given the positive educational experiences reported by users when using the videodisc as a self-contained lesson, we are optimistic about its use when imbedded in a more comprehensive curricular context

D The Potential of Different Use Modes

In this section we report on users' experiences in three different use modes. We observed disc use to find out what happened during each type of use and later questioned users about their experiences. In an effort to gain additional insight, we questioned users about their use mode preferences as well. Through an understanding of user experiences and preferences we hoped to shed light on the potential of the various use modes explored.

1. Users' Experiences

We observed students using the system in three different use modes: individual, pairs, and whole classrooms under teacher direction. While individual users were afforded the opportunity of working through the lessons solely under their own direction, students using the system in either the pair or classroom mode had to necessarily share their control and participation. The following sections will describe the experiences of users in each of the three use modes.

a. Individuals

Individual students appeared to enjoy working with the videodisc and its lessons. Many students smiled or laughed at certain sections and often reacted with positive exclamations such as, "Oh neat!" "That's cool." and "I like that."

In general students were quite successful in using the system to navigate through the lessons. Some, however, experienced minor difficulties. These usually involved understanding the function of a particular feature or determining what to do in order to continue in a lesson. The majority of students were able to resolve their problems without help from the observer, although all students

asked at least one question. Often, these questions were concentrated at the beginning of the lesson as students familiarized themselves with the system They asked observers questions such as "Can I turn it louder?" and "Do I read this?"

All students reacted verbally, to varying degrees, during their use of the videodisc. One student talked continuously to himself and the observer throughout the lesson. He also usually read the directions aloud. Other students tended to occasionally comment out loud on the lesson content with phrases such as "So, it eats fish," "Ah, there's the light," and "It's just amazing how they do that!" Students rarely commented on the system itself

Students' choices about which action box to touch were most strongly influenced by the built-in organization of the lessons and the accompanying worksheets. For example, many students pressed action boxes that would allow them to continue forward through the lesson in the most direct path.

While individual students' experiences with the disc proved engaging and successful, it would appear that students generally found the need to converse with another person about what they were doing.

b. Pairs

These sessions were extremely cooperative experiences, students were generally agreeable and helpful to one another. While the amount of interaction between students for the lesson activities differed, all pairs worked together at least some of the time. This collaboration ranged from lengthy discussions throughout the lesson about the material presented, to sharing worksheet responses only after they were filled out System navigation was also a congenial, shared procedure although it warranted little discussion from the students

When we began our data analysis, we looked in great detail at methods of negotiating system use how students decided when to

touch the screen, which action box to touch, and who would touch it. We discovered that although students occasionally talked among themselves about these choices, such explicit discussion about system use was rare.

When negotiation about system use did occur, pairs of students talked mostly about which action box to touch, especially when it involved the use of an interactive option: "Do you want to replay?" "Should we try chart?" In at least one of their lessons, most pairs talked a few times about specifically when to touch the screen by asking, "Are you ready?" or by saying, "Wait "

One student in each pair was usually the leader in touching the screen, although this arrangement was never verbally negotiated. For seven of the nine pairs, one student touched the screen more often for both lessons. For the remaining two, one touched more often in one lesson while the other touched more often in the second lesson. It is interesting to note that for one of these pairs, the leader in touching the screen was often being told what to press by the other student.

Most frequently, students touched the screen and moved forward in the lesson with no comment at all. Occasionally students would announce what action box they were about to hit, and, barring disagreement, they did so. On other occasions, one student would tell the other what box to hit. In the rare event that one student did disagree with another, the first student always gave in For example, if one said, "Wait," the other always agreed. In another instance, a student hit Redo: his partner did not want to redo the experiment so they returned to where they were.

How to complete the lessons elicited much more discussion between the pairs than system use. The amount of discussion for particular sections depended on the difficulty of the lesson and the number of accompanying worksheet questions Students generally discussed their answers before filling out their charts for "Plants and Light" and for "Animal Disguises " For "Edgerton," they

talked about their worksheets for the "Altered Time" and "Everyday Events" sections, but had less discussion as they filled out the "Milk and Water" worksheet. There was little discussion about the first two sections of "Pauling," probably because there were no worksheets for those sections. However, "Baffles," the last section of the lesson, caused considerable discussion as students determined at every step whether they had hit a baffle, and what their next moves should be. The "What's Hiding?" game in "Animal Disguises" also generated a great deal of discussion about where the camouflaged animals were located.

As was the case with individuals, the built-in organization of the lessons and accompanying worksheets were the strongest determinants of system use, although pairs did occasionally replay something they particularly liked or investigated an action box simply out of curiosity.

These results indicate that when pairs of students worked on one videodisc system, the experience was generally cooperative Much of the responsibility for decision making was shared between the two students, with each pair negotiating an arrangement that allowed for the involvement of both students. Shared videodisc use proved to elicit much discussion among users, focusing more on lesson content than on system use. It would seem that the actual mechanics of operating the videodisc system posed little problem for students, who most of the time did not talk about who should touch the screen. Pairs of students were thus able to manage the operation of the videodisc system easily, sharing opportunities for control and participation that resulted in what appeared to be a successful learning experience for both students

c. Classroom

In all four of the classroom sessions the teacher remained essentially in charge of the class, determining most of the time who would touch the screen, when an action box would be touched,

and which action box should be chosen On several occasions in every classroom, however, students would make these decisions In three of the classrooms, both the teacher and the students shared in touching the screen for one of the lessons. In only one classroom, however, did the students touch the screen consistently more than the teacher. This teacher invited students to touch the screen during both lessons:

> "One of the first things I want to get you people used to is the idea that this is something that we hope you would feel comfortable in using. So I'd like to ask, as much as possible, some of you nearer to the front to touch the screen."

The decision about which action box to touch was usually made under the direction of the teacher. In all but one of the classrooms the teacher alone usually determined which action box was touched; in the remaining classroom, the teacher based the decision on student requests or input. This teacher advised the students at the beginning of their first session, "You'll tell me what you want me to touch."

Teachers took student input for which action box to touch in several ways. At times, they would ask, "What do you want me to do?" and "Okay, do you want to see another example?" At other times, they would act on unsolicited student requests and suggestions. As classes became increasingly involved in the lesson, with students enthusiastically shouting out their suggestions and answers, three of the four teachers used consensus or even organized votes to reach a decision about a choice.

Students using the system in the classroom mode were asked in the interviews (n=13) whether they would prefer the teacher to decide what to do and where to go in the lesson, or would prefer to decide themselves. The students were equally divided in their preferences

Approximately half the students (46%) preferred to decide themselves. They stressed personal interests and abilities as

reasons for wanting control over the decision-making process Half of them felt that they would learn more by being able to spend additional time on specific sections of their own choosing, while one-third focused on the ability to do lessons of personal interest. Finally, one student pointed to the sense of personal accomplishment afforded by working on the system alone

> "I'd rather decide myself. Because if he decides and he gets it wrong, then I would think: well, I could have done better, but if I decided, then I would know that I would get it wrong I mean, if he gets it right, it's like, so what? But if I get it right it means I did something right "

Of the students preferring that the teacher decide (46%), some seemed to feel that the teacher knew more either about the subject matter (50%) or the system (16%), and should therefore make the decisions One student explained, "If he [the teacher] knows a lesson and you ask a question he can answer easily If you pick, it may be something he doesn't know about." Another student suggested that the teacher decide because, "I don't know how to work it, I might mess up the computer." Still another student preferred that the class decide together, explaining, "We were all together as a group and should work together."

Classroom students who were not interviewed were asked in their questionnaires (n=72) whether they would prefer the teacher to decide what to do and where to go in the lessons or whether they would prefer to decide themselves. A majority of these students (79%) explained that they would prefer to decide themselves, while one-fifth (21%) preferred that the teacher decide

Classroom use of the videodisc system provided fewer opportunities for students to take advantage of the potential control and participation offered by the medium. While students were often actively involved in expressing their opinions and preferences regarding which action box to chose and where to go in the lessons, the teacher retained the ultimate responsibility for

making decisions, which were usually based on a majority vote among students. Notably, only half of the students interviewed, who used the system in this mode, recognized its potential for providing a greater sense of control and a more individually tailored learning experience. The remaining students appeared to hold to the more traditional view of the teacher as the classroom authority and were therefore more willing to relinquish their own control in the learning experience. Student questionnaire responses provide more encouraging evidence in support of students' ability to recognize such videodisc potential.

2. Use of Interactive Options.

We explored in detail the interactive options used by students and teachers in the various use modes. We looked at how often they utilized options in general as well as which users tended to use particular options. We also explored how often interactive options were utilized in each of the four lessons. In so doing, we hoped to gain additional insight into how use modes influenced users' tendencies to exploit interactive options.

Our results (see Table 3) indicate that classroom users tended to use the highest number of interactive options, pairs of students used the next highest amount; individuals tended to use the fewest As previously noted, one pair of students used the interactive options an unusually high amount of times--43 in one lesson, in an attempt to find an appealing visual segment. It would seem that the number of users interacting with the system directly affects the amount of interactive option use. When more than one person interacts with the system there are increased opportunities for the kinds of discussion and disagreements which facilitate option use

Table 3

Interactive option use per lesson

	Use Mode		
	Individuals	Pairs	Classroom
Number of times options used			
Low-	0	0	0
High-	17	43	16
Mean-	4	6	8
Median-	4	3	9

We also looked at the average (mean) amount of interactive options used in each of the four lessons according to use mode (see Table 4). Users in all three use modes utilized interactive options most frequently during the "Edgerton" lesson. This lesson was designed to be exploratory in nature, a videodisc design strategy that seems to encourage a high level of interactivity For the remaining three lessons, individual and classroom use averages were similar, with users in both use modes tending to user interactive options next most frequently in the "Animal Disguises" lesson and the "Pauling" lesson, and least frequently in the "Plants and Light" lesson. Pairs of students, however, used interaotive options more frequently in the "Plants and Light" lesson than did students in the other two use modes This finding might be explained by students' confusion regarding the experimental design and certain visual images in the "Plants and

Light" lesson Students in the pair use mode were more likely to attempt to resolve their confusion in this lesson through discussion and interactive option use. Individual students had no partner with whom to discuss and work out problems and therefore may have been more likely to simply continue in the lesson Classroom students were afforded the benefit of a teacher who spent more time reading and discussing explanatory text screens and/or provided supplementary explanatory information when confusions arose

Table 4

Mean number of interactive options used per lesson

	Use Mode		
	Individuals	Pairs	Classroom
Lesson			
Edgerton	6	7	12
Animal Disguises	5	3	11
Pauling	4	2	8
Plants and Light	3	4	3

3 Use mode Preferences

When asked in what size group they would like to use the videodisc system, a majority of students (56%) expressed a preference for working in pairs. Among the remaining students, 19% said they would prefer to use the system with small groups of two or three other students, 16% said they would prefer individual use, and 9% said they would prefer to use the system with an entire class (see Table 5)

Table 5

Students' preferred use mode according to actual use mode

(n=43)

	Actual use mode			
	Individuals (n=12)	Pairs (n=18)	Classroom (n=13)	Total # (n=43)
Preferred use mode				
Alone-	4	1	2	7
With 1 Other-	7	15	2	24
With 2 or 3 Others-	1	2	5	8
With the Class-	0	0	4	4

We found that students' experiences with particular use modes influenced their preferences (see Table 5) Though the majority of students favored working with one other person, it was most

strongly preferred by the pairs This use mode was chosen by most of the pairs (83%), by over half of the individuals (58%), and some of the classroom students (15%) Although no students actually used the system in a small group, this use mode was the second most popular preference. It was preferred most strongly by students who used the system in the classroom mode Use of the videodisc alone or in classroom groups, although not as popular, tended to be preferred by students who had participated in these particular modes One-third of the individuals said they would prefer to use the videodisc alone; in contrast, only one or two students from the pair and classroom use modes preferred to use the videodisc alone One-third of the students from classroom groups said they would prefer using the videodisc with an entire class, in contrast, no students from the individual or pair use mode said they preferred to use the videodisc with an entire classroom.

It would seem that a lack of comparable experiences influenced, to a degree, user preferences. These findings also reflect students' relative satisfaction with their experiences, regardless of use mode.

We also found gender differences regarding the question of preferred use mode (see Table 6). Although both males and females preferred using the system in pairs (64% and 48% respectively), a majority of the students who would prefer to use the system alone were male. More than one-quarter of the males but only one female chose individual use. Correspondingly, the majority of students who would prefer to use the system with two or three others were female (75%) Perhaps females are indicating a preference for a more social learning experience. It should be noted, however, that classroom use was preferred slightly more by males than females

Table 6

Preferred use mode according to gender

(n=43)

Preferred use mode	Total # (n=43)	Female (n=22)	Male (n=21)
Alone-	7	1	6
With 1 Other-	24	14	10
With 2 or 3 Others-	8	6	2
With the Class-	4	1	3

Students speculated that using the system with one to three other students would give them an opportunity to share both socially and intellectually, while still retaining personal involvement with and influence over the system use

> "If it's just me and him, we can joke around but still learn You can discuss it with someone else while you're doing it If it's funny, you don't have to laugh with yourself "
>
> "Doing it alone is boring because there is no one to say, 'Oh, neat!' to "
>
> "It's more fun with another You have two brains instead of one."
>
> 'Definitely with one other student because if you can't answer a question, or need help, you can both be of service to each other "

"Because you can go over it with her and him and get their opinions, too If you're alone, you're confused and it's kind of a pain."

These comments indicate that students perceive the videodisc as a tool in an educational experience that should also be fun Such a perception appears to contribute to students' preference for using the disc in a mode which would allow them to share and enjoy the experience with others

Students who indicated a preference for pair and small group use said they would not like to use the system with as large a group as the classroom for several reasons they thought this setting had too much noise and confusion, they would not be able to go through the lessons as they liked, and they would not learn as much.

"In the whole class you couldn't get to do things by yourself as much and it would be hard to see Everybody would be crowding around the computer "

"With a lot of people, everyone wants to do it and you don't always get a turn."

"With lots of kids, it's hard to concentrate Everyone has different opinions "

"Because sometimes the class doesn't want to go back 'cause I don't understand it. But with my friends, they'd let me go back and review it, 'cause they're my friends."

"With a large group, it becomes less of your own answer and more of everyone else's so you don't learn as much "

Seven students, four of whom actually used the system individually, preferred to do it alone They felt it allowed them to do exactly what they wanted, that they learned more because they did all of it themselves, and that with no distractions they could concentrate better

"Because you'd get the most benefit out of it With two people it's split in half and you wouldn't learn as much because you're not doing it A kid would learn more if (she) had the opportunity to do it "

"Because you learn by yourself You can make your own decisions "

"I'd get more out of it. I'd be the only one concentrating on it. There would be no distractions "

Four students, all from the classroom groups at the city school, preferred the classroom use mode, each for a different reason. One student wanted the teacher there to answer questions Another felt that it was easier to learn with the whole class A third wanted more students around so there would be more ideas to discuss. The last student preferred the class as that was the only method he was familiar with.

When teachers considered the most appropriate use mode for the videodisc in science education, all said they believed that small group use (3-4 students) of the lessons would be the most effective way to use the videodisc lessons for several reasons. The small screen size made the system more appropriate for small groups of students rather than whole classroom groups. In addition, teachers felt that the system provided an opportunity for small groups of students to discuss concepts and then carry out research projects using the lessons as a starting point. One teacher suggested that small group use of the system "would allow students to build on the ideas of their peers "

Summary

Students in each of the use modes enjoyed using the videodisc but their experiences differed somewhat depending on use mode While individuals were able to maintain complete control over and sole participation in the lessons, they did not have the benefit of social interaction, which they appeared to desire, given their efforts toward conversation with observers Classroom students, on the other hand, were able to utilize the disc in a large social setting, which ultimately prevented many of them from interacting with the disc in a direct or meaningful way Pairs of students achieved the best of both of these use modes, they were afforded control, participation, and social interaction with a peer

Interactive option use also varied among the use modes and seems at least partially explainable in terms of the numbers of users interacting with the system. Classroom groups utilized more interactive options than students in the other two use modes, while individuals used the least amount. Although students in all use modes utilized options to review material, pairs of students were more likely to use a variety of interactive options to explore or resolve issues discussed with their partner as well as to understand the content of the lesson.

A variety of explanations for the pair and small group use preference might be offered. As previous sections have highlighted, students clearly appreciate the videodisc's capacity for affording user control and interaction. Certainly, the pair, small group, and individual use modes offer students a greater opportunity to exploit this capacity, thereby making preferences for these use modes understandable. These preferences are also supported by the finding that students found videodisc use interesting and appealing--an experience made even more enjoyable when shared. Students appeared to prefer an experience that was social and yet remained intimate enough to allow for sufficient

interaction with the disc Also, all use mode preferences were explained by at least some students in terms of the enhanced educational value afforded in their preferred use mode

Many students indicated a preference for the use mode in which they actually participated This may be the result of students having difficulty envisioning the benefits of a use mode beyond the one of their experience or may point to students' satisfaction with their own experiences. It seems that pairs and small groups permit users to exploit the widest range of the videodisc's attributes Other use modes, however, clearly present their own advantages for users, depending upon their individual learning styles and preferences

E. The Teacher's Role In Educational Use of Videodisc

As previously described, four teachers each taught two class sessions using SEEING THE UNSEEN The teachers were given some basic guidelines about the lessons prior to use, however, the instructional approach to using the lessons with students and the general structuring of the sessions was at the discretion of each teacher This strategy allowed teachers to find their own, best way of using the materials Moreover, researchers were able to observe different instructional approaches at work with large groups of students

Preparation time for the four teachers ranged from one to four hours. For two of the teachers, this included becoming familiar with the use of the videodisc system, understanding the design of two science lessons, and preparing a plan for using the materials with students. One teacher had considerable experience with the lessons before conducting the sessions, having consulted on the disc's design. One teacher was not completely familiar with the content of one lesson before conducting the sessions with students

Most teachers reported that they maintained their originally decided upon plan for using the lessons with students, although they reported that they found it helpful to "inject information to expand students' understanding" of the lessons One teacher was particularly concerned about introducing students to "all of the capabilites of the new technology and help screens at the beginning," wanting to then "let them decide what to do in subsequent lessons." This teacher also allowed time for students to "record data and discuss it both formally and informally," which she felt to be an excellent strategy for involving that particular group of learners Two teachers decided to "play it by ear" with less structured plans and to let the experience "flow in whatever direction the class went "

All four teachers felt that use of the videodisc medium made

their teaching easier and more exciting Three of the four teachers felt that their teaching of science was more effective using videodisc lessons, one was undecided Teacher preparation time for the use of two videodisc lessons seemed to directly affect both the quality of the instruction and the responses of individual teachers to their experiences using the system. As might be expected, teachers who spent more time familiarizing themselves with the system reported higher levels of comfort when using the system with students Likewise, those teachers who reported a more positive experience using the lessons with students listed slightly higher levels of preparation time before conducting their class sessions

1. Methods of Utilization

Detailed observations of each of the classroom sessions yielded results which illustrated three different methods of utilization of the technology: a) allowing the videodisc presentation to serve, in itself, as the classroom lesson; b) using the disc as a presentation with limited supplementary information, and c) incorporating the videodisc presentation as one of several teaching tools in a teacher designed lesson. Following are brief descriptions of how each of these methods were employed in classroom sessions

a Videodisc presentation as lesson

One of the teachers seemed more tentative in his use of the videodisc than the others. This teacher had spent the least amount of preparatory time with the system.

During his first classroom session, the atmosphere was quite informal, as students were gathered around the monitor, in chairs, or sitting on desk tops As the lesson progressed, this atmosphere developed into one in which students' participation fluctuated

between loud, enthusiastic involvement and disruptive boredom Possibly as a result of this experience, the teacher conducted his second session using the videodisc with a minimum of class discussion and stressed that he wanted students to work by themselves and not call out answers to questions

In his first session, the teacher offered a brief introduction to the lesson content, but said nothing about the technology He did point out to students that there was no written work and explained that students should "just watch and sort of participate mentally." These statements may have suggested a certain lack of seriousness about the activity and certainly underplayed the interactive nature of the videodisc The teacher opted to touch the screen himself for the duration of the lesson. He also read the instructions and directions appearing on the screen, "for those in the back." There was a notable lessening of attention as he read. Occasionally, this teacher did solicit suggestions and opinions from the students regarding the lesson. A certain core of students usually responded. In addition, several students offered suggestions for operating the program when the teacher seemed confused. These suggestions were readily accepted by the teacher

This teacher's sessions seemed to be very much guided by the built-in structure of the videodisc lesson. Rather than incorporating it into his own lesson plan, this teacher worked through lessons linearly. In this case, the videodisc was the lesson. Very little supplementary information was offered to students and, when it was, it was usually to clarify directions or choices, not to provide additional material related to content

b Videodisc presentation with supplementary information

Two other teachers also seemed to follow, fairly closely, the structure of the videodisc lesson, but offered considerably more elaboration on lesson content and the videodisc technology Both of these teachers provided students with introductions to the

technology, as well as the lesson's subject matter These teachers also exhibited a greater degree of comfort with and understanding of the system and the disc

In a session conducted by one of these teachers, the teacher offered a basic introduction to the system, highlighting the touchscreen feature as well as a more comprehensive introduction to the lesson ("Animal Disguises"), focusing the students, in this case, on the classifying nature of the content. She spent additional time clarifying the directions and read material that was printed on the screen for the benefit of those with poor visibility. For the most part, this teacher also worked through the lessons in a linear fashion, but offered a few elaborations on the lesson content, such as helping to define what constituted a "good category." In general, this teaoher spoke very little throughout the six animal disguise clips, seemingly allowing the videodisc to reveal the lesson. Even when there was confusion regarding a particular clip, the teacher replayed the clip twice before offering any supplementary, explanatory information. She was, however, constantly checking on whether students understood what was happening and what was expected of them.

o. Videodisc presentation as a teaching tool

The fourth teacher utilized the system in a manner that proved markedly different from the other three. This teacher seemed to incorporate the system as a tool into his own teaching methods, supplementing the disc material with xerox sheets and his own anecdotes regarding the subject matter presented Following a disc presentation, this teacher would often restate the material or instructions, or further reinforce the material through a brief question and answer period. Such discussions were often provoked by a student's expression of confusion. In these cases, the teacher would initiate a discussion among students regarding what they had seen on the disc and would offer supplementary information

in an effort to clarify a concept

Although the students were encouraged to interact with the system, their interaction was largely controlled and directed by the teacher, he would call on various students to touch the screen and guess at answers. He did however, make an effort to encourage a wide range of participation and even went so far as to rotate students' seats so that those in the back of the room could move closer to the system.

In addition, this teacher helped guide students in how they should respond to and behave with the system. He pointed out when they should concentrate on note taking and when they should focus on the video.

The experiences of these teachers suggest that familiarity with the system and personal teaching styles strongly influenced the manner in which teachers chose to incorporate the technology into their classrooms.

2. Teachers' Perceptions of the Videodisc

Teachers appeared to have an understanding of the potential of the videodisc as well as ideas regarding their own roles. They compared the technology with their own usual teaching styles and offered hypotheses about their roles when utilizing the disc

In discussing the use of videodisc lessons for instruction, teachers comparatively assessed the differences from and similarities to their usual styles of science instruction They noted that the videodisc was similar in offering many interactive activities and sharing of ideas between teacher and students, requiring students to respond to questions, and providing feedback about the responses. One teacher mentioned that the videodisc "repeated itself many times over," just as he said he does in teaching science. Another reported that his usual teaching style requires that students read aloud, as did the videodisc lessons

used in his classroom The same teacher also noticed that using the videodisc lessons was similar to his classroom style because it w. s easy to allow time both for discussion of concepts and for questions and answers during the lessons

The technical quality of "unique" video sequences was cited as a departure from what classroom teachers can provide Even with the visual support provided by the lessons, however, teachers felt that the feedback to students' responses was sometimes limited to being "either right or wrong," rather than giving students clues as to whether "an answer was way off base or very close "

Teachers also commented on their perceptions of the teacher's role when using the videodisc in an educational setting While teachers only had direct experience using the videodisc with a whole olassroom group, they hypothesized about the teaoher's role when using the disc with individuals or pairs of students.

All four teachers envisioned similar roles for a teacher using the videodisc lessons with entire classrcoms. They said that the teacher would be most effective as a "lesson leader" or "pace setter," who directed student use of the system. On the (her hand, opinions differed regarding the teacher's role when using the videodisc with individuals or pairs of students. One teacher felt the teaoher's role should be as a "resource person" who introduces a lesson and has students proceed on their own through the material. Another respondent suggested the teacher's role should be as a "prompter" for lower-level students as they used the material. Another saw the need for the teacher as a "faoilitator," promoting questions and answers during the lessons This would "cause students to wonder" by presenting similar situations (using other examples of the scientific process) as they worked through a videodisc lesson. One teacher's description of a successful use of the lessons by smaller groups of students included the teacher's ability to "set the material in a larger context" for students As the previous discussion illustrated, teachers appeared to have an

understanding of the potential of the videodisc as well as ideas regarding their own roles even when they did not behave in accordance with these beliefs

3 Summary.

Teachers appeared to appreciate the videodisc as an effective tool for teaching and learning. While their discussions, for the most part, indicated that they perceived the teacher's role in utilizing the disc as one of a guide or facilitator, their abilities to behave in this manner seemed somewhat limited; for the most part, teachers remained essentially in charge of the operation of the disc and the flow of the lesson. This may be due, in part, to a lack of experience and familiarity with the technology which led teachers to resort to their customary teaching methods. In considering teachers' utilization of the videodisc, it is important to keep in mind that they received minimal training with the videodisc technology and the videodisc lessons. We realized that more attention toward teacher training would have served to enhance their abilities to creatively incorporate disc use into their own most effective teaching strategies

While students in all of the classrooms proved to be generally involved in the lessons, regardless of the teacher's method of utilization, much of what is unique about the videodisc was not fully realized when the teacher maintained control over the technology Effective methods of utilization of a videodisc in a teacher directed classroom situation need to be investigated

VI. DISCUSSION AND CONCLUSION

Through a review of the literature we identified five key issues related to the educational application of videodisc technology. Our study of SEEING THE UNSEEN confirms that interactivity and user control, high quality visuals, pedagogical orientation, use mode, and the roles played by teachers are critical factors in exploiting the unique promise of this technology as an educational tool.

The interactive and visual nature of the medium proved to be the most salient and appreciated aspect of the technology. Students and teachers alike defined the technology (based on experience with our disc alone) as both participatory and illustrative. For students, these features set videodisc technology apart from other educational media and teaching techniques (e.g., books, television, computers, classroom lecture and discussion) and led them to conclude that videodiscs foster more effective and engaging learning experiences. Students repeatedly credited the visuals as making videodisc use interesting and fun.

Students' enthusiasm for and ease with SEEING THE UNSEEN may be related, in part, to their experiences with other media. Educational technologies, such as films and computers, were familiar but still special to students in the study. The presence of the videodisc system signaled a break in classroom routine that generated excitement. Knowledge of the conventions of television shows, computer software, and even video games (e.g., documentary narration, menus, varying levels of difficulty) may also have given students the know-how and confidence to approach the videodisc system without apprehension and adapt to it quickly. While no student had played a videodisc before, nearly all were able to use

the system readily and quickly solve problems with disc activities without the assistance of an observer

The ways students took advantage of the medium, including their use of various options, and their post-use level of comprehension indicate that a microenvironment designed to promote inquiry learning of science information and concepts can be successfully created on videodiscs. Indeed, compelling visual images, interactivity, and an exploratory approach proved to be a powerful combination which captured and retained the interest of students Students working alone or in pairs enjoyed actively working out problems because they could control the order and pace of information presented and gain access to material as desired Once involved, these students never gave up on a problem and if they had not completed an activity by the end of a 45-minute session, they wanted to continue

Clear and elucidating visuals and a high degree of interactivity are necessary to promote discovery learning, the pedagogical orientation embedded in SEEING THE UNSEEN The disc also showed us, however, that a discovery approach is easier to conceive than to implement, especially with a retrofit design strategy. For students to be discoverers--for them to take on the roles of investigators and use new information to reach meaningful conclusions--they must not only be allowed to explore but they must also be able to make sense of what they are exploring Relatively structured navigational aid and content guidance must be carefully balanced with flexibility in user control and choice Moreover, visual images must always be unambiguous--students cannot be expected to investigate visual data if they cannot see it or understand it We found that when the visual images were unclear, as in certain "Plants and Light" segments, students became frustrated in their attempts to gain information and their comprehension of the activity was impaired

Given their recognition of the advantages of interactivity and

high quality visuals, it is not surprising that most students said they would prefer not to use the disc in a classroom Classroom groups restricted personal involvement--there were too many students demanding varying options, the teacher usually determined direction and path, and the screen was too small for everyone to view the video images or read text Those students who were able to maintain a high degree of involvement were forced into competitive interactions in which they had to shout out their answers, opinions, and requests, many of which were not addressed

Students did, however, consider the social context of disc use to be very important. While most recognized the problems inherent in large group use, they also said they would prefer not to use the disc alone. They perceived pairs or small groups as the best use mode Apparently students felt that in pairs and small groups they could exploit a wide range of videodisc characteristics, particularly control and participation, while benefiting from the manageable and interesting input of just one or two other people Interestingly, female students showed a greater appreciation for the benefits of pair and small group use than males. It may be that girls generally prefer a more social and intimate learning situation.

It must be noted that many students said they preferred the use mode that they had experienced as part of the study The fact that students in each use mode reported enriching experiences suggests that the technology can be successfully utilized in a variety of settings

The design of SEEING THE UNSEEN may also have influenced students' use mode preferences. As a design sampler intended to encourage discovery learning through various forms of interaction, the disc may be less suited to large group use The explorations encouraged by disc activities are more effectively accomplished by small groups of learners We therefore hypothesize that specific videodisc designs may be more appropriate to certain use modes

While an inquiry-oriented disc may be ideal for small groups of learners working independently, an archival disc may prove ideal for whole classes working under the direction of a teacher Further research is needed to determine the effectiveness of different videodisc designs for particular learning settings, teaching strategies, and instructional goals.

Another area requiring further exploration is the role played by teachers when videodiscs are used in schools Students' acceptance and appreciation of the control afforded them by the videodisc suggests that teachers should provide opportunities for exploiting this advantage, either directly or indirectly.

When discs are used by pairs or small groups, teachers' roles are almost always indirect Teachers usually introduce and follow-up on the activity by providing a curricular context for out-of-classroom use. This role is analogous to that fostered by computer use in a media lab. It is the classroom role that remains uncertain. While teachers in the study recognized that their most effective role might be as guide rather than director, several had difficulty assuming this role. Some allowed students to interact freely with the disc, others took complete control of disc operation. None of the teachers fully exploited the disc's inquiry approach.

The answer may lie both in designing discs that suit existing teaching styles and settings, and in teaching teachers how to take advantage of the new technology Teacher training that explains the potentials and constraints of the medium and reviews the content of an individual disc could lead to more effective uses of the technology. Experimental lesson plans, which show teachers how to incorporate specific videodiscs into existing curricula, might be developed and tested In addition, examining teaching models that work with other educational technologies might suggest new ways to use videodiscs in the classroom.

In conclusion, this study supports the promise of videodisc

technology for educational use The medium appears to provide students with unrealized opportunities for taking control of their own learning in an educational experience that is interesting, social, and fun The significance of the technology to classroom teachers is less clear Future research will explore the place of videodiscs in the nation's classrooms

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APPENDIX A:

Instruments

TIME	HITS	2X	COMMENTS	ACTIVITY

91

5/2/86 CLASS--WRITTEN

STUDENT QUESTIONNAIRE

WHAT DISGUISES DO ANIMALS USE?
HOW DOES LIGHT AFFECT PLANTS?

Now that you've finished, we'd like to know what you thought about the interactive videodisc system and the lessons. Please fill out this questionnaire during the remaining class time. Thank you.

Grade _____ Age_____ Date_____

Girl _____ or Boy_____ Teacher_____

1. What did you like most about the videodisc system and the lessons?

2. What did you like least about the videodisc system and the lessons?

3a. How was learning in class on the videodisc system the same as what you usually do in class?

b. How was learning in class on the videodisc system different from what you usually do in class?

4a. How would you most like to use this videodisc system? (CHECK ONE.)

___with the whole classroom, taught by the teacher, like you did today

___alone

___with one other student

___with two or three other students

b. Why?

5a. Was there any time you would have made a different choice than the teacher did about where to go and what to do in the lesson? (CHECK ONE.)

____ Yes

____ No

b. If yes, what was it?

6a. Would you rather have the teacher decide what to do and where to go in the lesson, or would you rather decide yourself? (CHECK ONE.)

_____ I'd rather have the teacher decide.

_____ I'd rather decide myself.

b. Why?

7. Do you think it would be easy or hard to use the videodisc system by yourself? (CHECK ONE.)

_____ Easy

_____ Hard

8a. How clear were the directions for doing the lessons?

_____ The directions were always clear.

_____ Sometimes I didn't understand the directions.

b. If there were any directions you didn't understand, what were they?

9. How much did you like each of these features of the videodisc system? (CHECK ONE BOX FOR EACH FEATURE.)

FEATURES:	Very Much	Some-what	Not Very Much
a. Watching the video sections	____	____	____
b. Listening to a voice on the system	____	____	____
c. Reading words on the screen (or having the teacher read them)	____	____	____
d. Being able to choose what to do and where to go in the lesson by using pause, replay, go ahead, etc.	____	____	____
e. Learning about something new	____	____	____

10a. How well did you understand the lesson "What disguises do animals use?"? (CHECK ONE.)

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from that lesson that you didn't know before?

11a. How well did you understand the lesson "How does light affect plants?"? (CHECK ONE.)

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from that lesson that you didn't know before?

15a. Which lesson did you like better? (CHECK ONE.)

_____ What disguises do animals use?

_____ How does light affect plants?

b. Why?

17. Please write any other comments you have about the videodisc system and the lessons.

5/2/86 CLASS--WRITTEN

STUDENT QUESTIONNAIRE

HOW DO SCIENTISTS STUDY THINGS THEY CAN'T SEE?
WHAT HAPPENS WHEN TIME IS ALTERED?

Now that you've finished, we'd like to know what you thought about the interactive videodisc system and the lessons. Please fill out this questionnaire during the remaining class time. Thank you.

Grade _____ Age_____ Date_____

Girl_____ or Boy_____ Teacher_____

1. What did you like most about the videodisc system and the lessons?

2. What did you like least about the videodisc system and the lessons?

3a. How was learning in class on the videodisc system the <u>same</u> as what you usually do in class?

b. How was learning in class on the videodisc system <u>different</u> from what you usually do in class?

4a. How would you most like to use this videodisc system? (CHECK ONE.)

___with the whole classroom, taught by the teacher, like you did today

___alone

___with one other student

___with two or three other students

b. Why?

5a. Was there any time you would have made a different choice than the teacher did about where to go and what to do in the lesson? (CHECK ONE.)

____ Yes

____ No

b. If yes, what was it?

6a. Would you rather have the teacher decide what to do and where to go in the lesson, or would you rather decide yourself? (CHECK ONE.)

_____ I'd rather have the teacher decide.

_____ I'd rather decide myself.

b. Why?

7. Do you think it would be easy or hard to use the videodisc system by yourself? (CHECK ONE.)

_____ Easy

_____ Hard

8a. How clear were the directions for doing the lessons?

_____ The directions were always clear.

_____ Sometimes I didn't understand the directions.

b. If there were any directions you didn't understand, what were they?

9. How much did you like each of these features of the videodisc system? (CHECK ONE BOX FOR EACH FEATURE.)

FEATURES:	Very Much	Some-what	Not Very Much
a. Watching the video sections	____	____	____
b. Listening to a voice on the system	____	____	____
c. Reading words on the screen (or having the teacher read them)	____	____	____
d. Being able to choose what to do and where to go in the lesson by using pause, replay, go ahead, etc.	____	____	____
e. Learning about something new	____	____	____

10a. How well did you understand the lesson "How do scientists study things they can't see?"? (CHECK ONE.)

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from that lesson that you didn't know before?

11a. How well did you understand the lesson "What happens when time is altered?"? (CHECK ONE.)

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from that lesson that you didn't know before?

15a. Which lesson did you like better? (CHECK ONE.)

_____ How do scientists study things they can't see?

_____ What happens when time is altered?

b. Why?

13. Please write any other comments you have about the videodisc system and the lessons.

CLASS USE IMPRESSION 5/2/86

STUDENT QUESTIONNAIRE

INTERVIEWER _____ SCHOOL_____

STUDENT_____ DATE_____

TEACHER_____

LESSONS COMPLETED: AD AND PAUL ____ EDGER AND PAUL____

Now that you've finished, I'd like to ask you a few questions about what you thought about the interactive videodisc system you used and the lessons you took.

START TIME_____

AGE_____ GRADE_____

1. If someone asked you what the videodisc was like, and what you did in the lessons, what would you tell them?

2. What did you like most about the videodisc system and the lessons?

3. What did you like least about the videodisc system and the lessons?

4. There are different ways of learning about something. How do you think learning on the videodisc system is the same as or different from learning from TV or a movie? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

5. How do you think learning on the videodisc system is the same as or different from learning on a computer? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

6. How do you think learning on the videodisc system is the same as or different from learning from a book? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

7. How do you think learning on the videodisc system is the same as or different from learning in a classroom? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

8a. How was learning on the videodisc system the same as what you usually do in class?

b. How was it different from what you usually do in class?

9a. How would you most like to use this videodisc system:

___with the whole classroom, taught by the teacher, like you did today
___alone
___with one other student
___with two or three other students

b. Why?

10. Was there any time you would have made a different choice than the teacher did about where to go and what to do in the lesson? Where?

11. Would you rather have the teacher decide what to do and where to go in the lesson, or would you rather decide yourself? Why?

12. Do you think it would be easy or hard to use the videodisc system by yourself? [DO NOT PROBE FOR THIS ONE.]

13. How clear were the directions for doing the lessons? [PROBE FOR SPECIFIC AREAS OF CONFUSION, IF APPLICABLE.]

14. How much did you like each of these features of the videodisc system?

	Very Much	Some-what	Not Very Much
a. Watching the video sections	____	____	____
b. Listening to a voice on the system	____	____	____
c. Reading words on the screen yourself (or having the teacher read them)	____	____	____
d. Being able to choose what to do and where to go in the lesson by using pause, replay, go ahead, etc.	____	____	____
e. Learning about something new	____	____	____

15. Which lesson did you like better? Why?

16. What do scientists do?
(When scientists go to work, what do they spend their day doing?)
(Can you think of any scientists? What do you think they do?)

17. How do you think what you did on the videodisc system is the same as or different from what a scientist does in real life?

18. Have you ever used a computer before? [+ When/where]

19. What is your most favorite subject in school? [ALL SUBJECTS COUNT, INCLUDING GYM AND ART]

20. What is your least favorite subject in school? [ALL SUBJECTS [illegible] INCLUDING GYM AND ART]

21. Is there anything else you would like to say about the videodisc system and the lessons?

END TIME_____

TOTAL TIME_____

4/2/86 4/4/86

Individuals & Pairs

STUDENT QUESTIONNAIRE

INTERVIEWER _____ SCHOOL_____

STUDENT_____ DATE_____

USE MODE: INDIVIDUAL_____ PAIR_____ CLASS_____

LESSONS COMPLETED: AD AND P&L ____ EDGER AND PAUL____

Now that you've finished, I'd like to ask you a few questions about what you thought about the interactive videodisc system you used and the lessons you took.

START TIME_____

AGE_____ GRADE_____

1. If someone asked you what the videodisc was like, and what you did in the lessons, what would you tell them?

2. What did you like <u>most</u> about the videodisc system and the lessons?

3. What did you like <u>least</u> about the videodisc system and the lessons?

4. There are different ways of learning about something. How do you think learning on the videodisc system is the same as or different from learning from TV or a movie? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

5. How do you think learning on the videodisc system is the same as or different from learning on a computer? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

6. How do you think learning on the videodisc system is the same as or different from learning from a book? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

7. How do you think learning on the videodisc system is the same as or different from learning in a classroom? [PROBE FOR BOTH SIMILARITIES AND DIFFERENCES.]

STUDENT QUESTIONNAIRE P.3

8. How would you most like to use this videodisc system:

___alone [AS APPROPRIATE: like you did]
___with one other student [AS APPROPRIATE: like you did]
___with two or three other students
___or with the whole classroom, taught by the teacher?

Why?

9. How easy or hard was it for you to use the videodisc system? [DO NOT PROBE FOR THIS ONE.]

10. Did you always know where you were in the disc and how to get to the next place or were there any places you were confused?

11. Did you understand what all the boxes you touched on the bottom of the screen meant, or were any of them unclear?

12. [LOOK FOR A USE PATTERN.] I noticed you never used (AS APPROPRIATE: PAUSE/Replay/Thoughts/????/Redo). Why? (What do you think they meant? What would have made their meaning more clear to you?)

13. Were the directions for doing the lessons and using the videodisc system clear to you, or were there some you didn't understand?

14. When you were using the videodisc, did you like touching the screen very much, somewhat, or not very much?

15. When you were using the videodisc, you could choose what you wanted to do by using pause, replay, go ahead, etc. Did you like that very much, somewhat, or not very much?

16. What do you think scientists do?
(When scientists go to work, what do they spend their da, doing?)
(Can you think of any scientists? What do you think they do?)

17. How do you think what you did on the videodisc system is the same as or different from what a scientist does in real life?

18. Have you ever used a computer before? [X When/where]

19. What is your **most** favorite subject in school? [ALL SUBJECTS COUNT, INCLUDING GYM AND ART]

20. What is your least favorite subject in school? [ALL SUBJECTS COUNT, INCLUDING GYM AND ART]

21. Is there anything else you would like to say?

END TIME_____

TOTAL TIME_____

5/2/86

Class version

ANIMAL DISGUISES

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished,
I'd like to ask you some questions about the lesson you did.

START TIME _____

1. What do you think this lesson was about?

2. Let's talk about the chart you did. What was the first category you made? (Can you describe it to me?)

3. Describe you second category to me. How is it different from your first category?

4. [IF APPROPRIATE.] Describe your third category to me. How is it different from your first and second categories?

5. [IF STUDENT DID NOT MAKE ANIMAL DISGUISES CATEGORIES.] If you had to categorize the animals according to what disguises they used, how would you do it? [AFTER THEY MENTION CATEGORIES, ASK WHICH ANIMALS FROM LIST WOULD FIT INTO EACH CATEGORY.]

6. a. [IF APPROPRIATE.] While you were watching the first six clips, did any animals seem to fit into more than one category? Which one(s) and how?

b. What did you do about it?

7. Why do you think we had you make categories?

8. Why is it useful to put things into categories?

9. Why might it be a good idea to write down your categories on a chart?

10. Let's say you were going to write a paper about what the animals in your neighborhood eat. How would you organize what you found out about all the foods the animals ate?

11a. How well did you understand this lesson?

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from this lesson that you didn't know before?

END TIME _____

TOTAL TIME _____

Class version

12/86

PLANTS AND LIGHT

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished this lesson, I'd like to ask you some questions about what you did.

START TIME _____

1. What was this lesson about?

2. Remember the experiment when you touched the sun on different parts of the screen? Tell me about that experiment. (What did you learn?) [NOTE WHETHER STUDENT LOOKED AT CHART]

3. In the second experiment you looked at plants in different colors of light. Tell me about that experiment. (What did you learn?) [NOTE WHETHER STUDENT LOOKED AT CHART]

PLANTS AND LIGHT P. 2

4. In the third experiment you looked at plant shoots in light. Tell me about that experiment. (What did you learn?) [NOTE WHETHER STUDENT LOOKED AT CHART]

5. Why do you think we used two shoots and not just one for these experiments?

6. How did you figure out the answers for the prediction questions? (Do you see any way in which the prediction questions were related to the experiments?)

7. We've just looked at the effect of light on plants. How could you study the effect of <u>water</u> on plants?

8a. How well did you understand this lesson?

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from this lesson that you didn't know before?

END TIME _____

TOTAL TIME _____

5/2/86

Class version

EDGERTON

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished this lesson, I'd like to ask you some questions about it.

START TIME _____

1. What was this lesson about?

2. The events you just saw were filmed using either high speed or time lapse techniques. Can you tell me what it means to film something using high speed techniques?

3. Can you tell me what it means to film something using time lapse techniques?

4. Can you think of something that happens too fast for you to see very well? [PROBE FOR ONLY TWO EXAMPLES.]

5. You mentioned [EXAMPLES]. Pick one of those and tell me how you could study that.

6. What would you see that you couldn't see before?

7. Can you think of something that happens too slow for you to see very well? [PROBE FOR ONLY TWO EXAMPLES.]

8. You mentioned [EXAMPLES]. Pick one of those and tell me how you could study it.

9. What would you see that you couldn't see before?

10. Why would someone want to study something using high speed or time lapse techniques?

11a. How well did you understand this lesson?

_____ Very well

_____ Pretty well

_____ Not very well

(cont.)

b. What did you learn from this lesson that you didn't know before?

5/2/86

Class version

PAULING

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished,
I'd like to ask you some questions about the lesson you did.

START TIME _____

1. What do you think this lesson was about?

2. What steps did Dr. Pauling take to solve the problem of what was in the box?

3. Is his way of solving the problem like guessing or not?

4. Did Dr. Pauling have a plan of how to solve the problem? What was it?

5. What did you think was in the box? How did you figure that out?

6. In the Baffles game, how did you go about figuring out where the baffles were placed?

7. How is doing Baffles the same as or different from how Dr. Pauling figured out what was in the box?

8 a. How well did you understand this lesson?

_____ Very well

_____ Pretty well

_____ Not very well

b. What did you learn from this lesson that you didn't know before?

END TIME _____

TOTAL TIME _____

1/4/86

Individuals; Pairs

PLANTS AND LIGHT

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished this lesson, I'd like to ask you some questions about what you did.

START TIME _____

1. What was this lesson about?

2. Remember the experiment when you touched the sun on different parts of the screen. Tell me about that experiment. (What did you learn?) [NOTE WHETHER STUDENT LOOKED AT CHART]

3. In the second experiment you looked at plants in different colors of light. Tell me about that experiment. (What did you learn?) [NOTE WHETHER STUDENT LOOKED AT CHART]

4. In the third experiment you looked at plant shoots in light. Tell me about that experiment. (What did you learn?) [NOTE WHETHER STUDENT LOOKED AT CHART.]

5. Why do you think we used two shoots and not just one for these experiments?

6. How did you figure out the answers for the prediction questions? (Do you see any way in which the prediction questions were related to the experiments?)

7. We've just looked at the effect of light on plants. How could you study the effect of <u>water</u> on plants?

8. What did you learn from this lesson that you didn't know before?

END TIME _____

TOTAL TIME _____

4/4/86

Individuals; Pairs

EDGERTON

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished this lesson, I'd like to ask you some questions about it.

START TIME _____

1. What was this lesson about?

2. The events you just saw were filmed using either high speed or time lapse techniques. Can you tell me what it means to film something using high speed techniques?

3. Can you tell me what it means to film something using time lapse techniques?

4. Can you think of something that happens too fast for you to see very well? [PROBE FOR ONLY TWO EXAMPLES.]

5. You mentioned [EXAMPLES]. Pick one of those and tell me how you could study that.

6. What would you see that you couldn't see before?

7. Can you think of something that happens too slow for you to see very well? [PROBE FOR ONLY TWO EXAMPLES.]

8. You mentioned [EXAMPLES]. Pick one of those and tell me how you could study it.

9. What would you see that you couldn't see before?

10. Why would someone want to study something using high speed or time lapse techniques?

11. What did you learn from this lesson that you didn't know before?

END TIME _____ TOTAL TIME _____

1/4/86

Individuals & Pairs

ANIMAL DISGUISES

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished,
I'd like to ask you some questions about the lesson you did.

START TIME _____

1. What do you think this lesson was about?

2. Let's talk about the chart you did. What was the first category you made? (Can you describe it to me?)

3. Describe you second category to me. How is it different from your first category?

4. [IF APPROPRIATE.] Describe your third category to me. How is it different from your first and second categories?

5. [IF STUDENT DID NOT MAKE ANIMAL DISGUISES CATEGORIES.] If you had to categorize the animals according to what disguises they used, how would you do it? [AFTER THEY MENTION CATEGORIES, ASK:WHICH ANIMALS FROM LIST WOULD FIT INTO EACH CATEGORY.]

6. a. [IF APPROPRIATE.] While you were watching the first six clips, did any animals seem to fit into more than one category? Which one(s) and how?

b. What did you do about it?

ANIMAL DISGUISES P.2

7. Why do you think we had you make categories?

8. Why is it useful to put things into categories?

9. Why might it be a good idea to write down your categories on a chart?

10. Let's say you were going to write a paper about what the animals in your neighborhood eat. How would you organize what you found out about all the foods the animals ate?

11. What did you learn from this lesson that you didn't know before?

END TIME _____

TOTAL TIME _____

1/7/86

Individuals & Pairs

PAULING

INTERVIEWER _____ SCHOOL _____

STUDENT _____ DATE _____

USE MODE: INDIVIDUAL ___ PAIR ___(PARTNER_____) CLASS _____

AGE _____ GRADE _____

Now that you've finished,
I'd like to ask you some questions about the lesson you did.

START TIME _____

1. What do you think this lesson was about?

2. What steps did Dr. Pauling take to solve the problem of what was in the box?

3. Is his way of solving the problem like guessing or not?

4. Did Dr. Pauling have a plan of how to solve the problem? What was it?

5. What did you think was in the box? How did you figure that out?

6. In the Baffles game, how did you go about figuring out where the baffles were placed?

7. How is doing Baffles the same as or different from how Dr. Pauling figured out what was in the box?

8. What did you learn from this lesson that you didn't know before?

END TIME _____

TOTAL TIME _____

TEACHER QUESTIONNAIRE
SEEING THE UNSEEN

5/9/86

NAME_____ DATE_____

GRADE(S) TAUGHT _____

SUBJECT(S) TAUGHT_____

NUMBER OF YEARS IN TEACHING FIELD_____

NUMBER OF YEARS TEACHING SCIENCE_____

PLEASE ANSWER QUESTIONS 1 - 22 IN REFERENCE TO THE TWO LESSONS YOU TAUGHT IN THE CLASSROOM. FEEL FREE TO MAKE ANY ADDITIONAL COMMENTS ABOUT THE REMAINING TWO LESSONS IN QUESTION 23.

1a. What do you see as the major strengths for classroom use of each of the two videodisc lessons you taught?

b. What do you see as the major weaknesses for classroom use of each of the two videodisc lessons you taught?

2. How much time did you spend in preparation for teaching these lessons? (Please include the amount of time you spent becoming familiar with the lessons, as well as in planning the presentation.)

3. How did you plan to carry out the lesson? Did you carry out the lesson as you had planned or did you do anything differently? If you made any changes, describe what you did differently and why.

4. Is there anything that happened in the class that was different from what you expected?

5a. If you were to teach these two lessons over again, in what ways would you teach them the same?

b. In what ways would you teach them differently?

6a. Which lesson did you prefer teaching? Why?

b. Which lesson is more appropriate for classroom use? Why?

7a. How would you characterize your students' reactions to the videodisc system and the lessons? Would you say they liked them

_____very much.

_____somewhat.

_____not very much.

_____not at all or

_____the reaction was mixed?

b. Please write down any noteworthy comments your students made about the videodisc system and the lessons.

8a. How well do you think the students understood the subject matter?

_____Students understood everything.

_____There were some things they didn't understand.

b. If applicable, please identify any areas of confusion and suggest possible lesson revisions.

9. What do you think students learned from each of these lessons that they didn't know before?

10a. How was teaching with the videodisc similar to the way you usually teach?

b. How was teaching with the videodisc different from the way you usually teach?

11. Did using this videodisc make your teaching

_____easier or _____more complicated?

_____more fun or _____less fun?

_____more effective or _____less effective?

p 6.

12. What do you see as the role of the teacher in the following videodisc use modes?

a. individual

b. pair

c. small group (three or four students)

d. whole classroom

13a. What do you think would be the most effective use mode for this videodisc?

_____Individual

_____Pair

_____Small group (three or four students)

_____Whole classroom

_____Depends on lesson (Please explain.)

b. Why?

14. Was the time allotted to teach your lessons

_____too much.

_____too little or

_____about right?

15b. Were the lessons appropriate for the grade level(s) of the students you taught?

_____Very appropriate

_____Somewhat appropriate

_____Not at all appropriate

b. Why?

16. For what grade range do you think the videodisc lessons are appropriate?

17. Please suggest any design changes which would make the videodisc lessons more effective for classroom use.

18a. Would you use all or part of these two videodisc lessons again with the <u>same</u> class?

_____Yes

_____No

b. If so, how? If not, why not?

19a. Would you use these two lessons again with a <u>different</u> class?

_____Yes

_____No

b. If so, how? If not, why not?

20. If you were to use these videodisc materials on a regular basis, what additional materials would be helpful in integrating the lessons into your instruction plan?

21. What do you think would be useful or helpful information to be included in a workshop or print material introducing the videodisc and lessons?

22. What suggestions would you give other teachers planning to use the videodisc and the lessons?

23. If you like, please comment about the two videodisc lessons you didn't teach. When you make your comments, refer to any of the above questions.

24. Have you taught using any of the following technologies before?

_____Television

_____Computers

_____Other (please specify)

25. Is there anything else you would like to say about your experience with the videodisc system and the lessons?

THANK YOU VERY MUCH !

APPENDIX B:

Worksheets

NAME: _____

ANIMAL DISGUISES CHART

CATEGORIES	VIDEO SEQUENCES											
	Walkingstick & Praying Mantis	Monarch & Viceroy Butterflies	Scorpion & Tailless Whip Scorpion	Weaver Bird & Nest	Boa & Snake	Blue Jay & Purple Martin	Spider & Ant	Angler & Butterfly Fish	Horned Lizard & Ants	Caterpillar & Ant	Thunderbird & Lightning Snake	Beetle & Co

WHAT DISGUISES DO ANIMALS USE?

Name: _____

Disguise Parade

NOTES

What are the names of the animals?

Where does the interaction take place?

Which animal is the predator and which is the prey?

Does an animal look like its surroundings?

Does an animal look or act like another animal?

NAME: _____

EXPERIMENT #1. How do plants respond to light from different directions?

RESPONSE OF PLANTS	POSITION OF LIGHT		
	LEFT OF PLANTS	ABOVE PLANTS	RIGHT OF PLANTS
BEND TO THE LEFT			
NOD BUT DO NOT BEND			
BEND TO THE RIGHT			
NO OBSERVABLE RESPONSE			

NAME: _____

EXPERIMENT #2: How do plants respond to different colors of light?

RESPONSE OF PLANTS	COLORS OF LIGHT (the light always shines from the left)		
	RED	BLUE	GREEN
BEND TOWARD LIGHT			
BEND AWAY FROM LIGHT			
NOD BUT DO NOT BEND			
NO OBSERVABLE RESPONSE			

NAME. _____

EXPERIMENT #3. Which part of a plant senses light?

RESPONSE OF SHOOTS	PART OF SHOOT						
	TIP					STEM	
	CUT TIP	CONTROL TIP	COVERED TIP	CONTROL TIP		COVERED STEM	CONTROL STEM
BEND TOWARD LIGHT							
BEND AWAY FROM LIGHT							
NO OBSERVABLE RESPONSE							

WHAT HAPPENS WHEN TIME IS ALTERED?
Milk and Water

Name: _____

Observation Questions

Describe the surfaces onto which the milk and water drops fall.

How do the drops behave on each surface?

What shape are falling drops?

How do rivers of water flow?

How does a liquid's behavior change when it is in different quantities?

WHAT HAPPENS WHEN TIME IS ALTERED? Name: _____

Altered Time

OBSERVATION CHART

Video Sequences	High-Speed	Time-Lapse
1. Spider's Web		
2. Cat and Milk		
3. Cup of Milk		
4. Fern		
5. Dandelion		
6. Hummingbird		
7. Clouds		
8. Orange		
9. Football		
10. Tennis ball/racket		
11. Starfish		
12. Milk Drop		
13. Vines		
14. Water Drop		

WHAT HAPPENS WHEN TIME IS ALTERED?
Everyday Events

Name: _____

Observation Questions

[Alarm Clock]

How does the alarm's pitch change when the ringing sound is slowed down?

[Coke Bottle]

What can be said about the number and size of glass pieces?

[Deck of Cards]

How many face cards do you see? In what order do they appear?

[Popcorn]

What actions do you see only in the high-speed film?
What actions still happen too fast to be seen?