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ABSTRACT

This paper presents research on the concept of idealized learning environments called Havens that facilitate learning, introduces the topic of technologically-created Havens, and discusses various components of Havens that can facilitate comprehension. Three experiments involving college students at Vanderbilt University are described. Designed to illustrate and evaluate some procedures for creating Havens for learning, these experiments used videotape and computer-controlled videodiscs to create meaningful environments that could be shared by students and mediators. When the effects of learning in these Haven-like environments were compared with the effects of environments that are often found in schools, the results were positive, suggesting that more sophisticated uses of technology, especially computer-controlled interactive videodisc, should have even greater benefits on comprehension and learning. Also included are descriptions of some videodisc-based Havens that are currently being developed at Vanderbilt University. (JB)

# Havens for Learning: Toward a Framework for Developing Effective Uses of Technology

John D. Bransford

Robert D. Sherwood

Charles K. Kinzer

Ted S. Hasselbring

George Peabody College of Vanderbilt University

Running Head: HAVENS

## Author Notes

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John Bransford (Ph.D.) is Professor of Psychology & Education and Director, Learning Technology Center, Vanderbilt University. Robert Sherwood (Ph.D.) is Assistant Professor of Education and is Associate Director of the Learning Technology Center. Charles Kinzer (Ph.D.) is an Assistant Professor of Education and is a Research Scientist in the Learning Technology Center. Ted Hasselbring (Ed.D.) is Associate Professor of Special Education and Associate Director, Learning Technology Center.

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Abstract

Many uses of technology fall short of their potential because they are not embedded in appropriate teaching contexts. This paper considers the concept of idealized contexts, defined as Havens, and discusses various components of Havens that can facilitate comprehension and learning. These components include the opportunity to learn in semantically rich contexts, the availability of mediators who can guide the learning, and the importance of understanding how new knowledge can function as conceptual tools that facilitate problem solving. Three experiments are presented that demonstrate some of the advantages of learning in Haven-like environments. The experiments involve very simple uses of technology, yet they show positive results. The results suggest that more sophisticated uses of technology, especially computer-controlled interactive videodiscs, should have even greater benefits on comprehension and learning. Some videodisc-based Havens that are currently being developed at Vanderbilt are described.

Recent advances in technology have created the potential for designing environments (microworlds) that can have powerful effects on learning. For example, Papert (1980) argues that it might be possible to create a "mathland" that makes it as easy and natural to learn about mathematics as it is for children to learn their native language. Similarly, a number of theorists argue that well-designed games and simulations can facilitate people's abilities to learn (e.g., Bork, 1981; Di Sessa, 1980; Malone, 1981; White, 1984). The development of systems for diagnosing systematic patterns of errors (e.g., Burton & Brown, 1982) and for offering individualized tutoring (e.g., Lesgold, 1984; Sleeman & Brown, 1982) provide extra advantages for increasing learning. In addition, the ability to combine computers with videodiscs provides opportunities that are just beginning to be tapped (e.g., Eastmond, 1984; Lawler & Papert, 1985; Parsloe, 1983).

Despite the promising potentials of technology, it seems clear that many applications are less-than-optimal and lack research support. As an illustration, consider claims about the benefits of learning to program computers in Logo (e.g., Papert, 1980). One interpretation of Papert's argument is that students who engage in Logo programming will spontaneously derive generalizable benefits such as increased abilities to break problems into smaller units, debug unsuccessful attempts to solve problems, and so forth. Ideally, such students should show transfer from Logo experiences to non-Logo tasks. Efforts to provide strong, empirical evidence for such transfer have often been unsuccessful and have led to debates about the value of Logo (e.g., Green, 1985; Pea & Kurland, 1983). Moursund (1983) makes the following comments:

It feels to me like Logo has been oversold. Marketing experts have done their job, but that isn't what has oversold Logo. Educators have done it to themselves. In looking for "the answer" in computing, these educators have latched onto Logo. It obviously is part of an answer, but transforming a partial solution into a panacea is damaging, both to education and to the potential of Logo. (p.3).

Many problems with Logo derive from the assumption that Logo programming will spontaneously develop generalizable skills and attitudes. An alternate assumption is that Logo programming has the potential for such development, but only if it is embedded in a broader context of teaching activities. For example, several investigators report that students taught using an unstructured, "discovery" approach to Logo often spend a considerable amount of time engaging in unsystematic trial and error behavior and are less likely to master basic aspects of programming than are students who receive more structured instruction (e.g., Delclos, Littlefield & Bransford, in press; Kinzer, Littlefield, Delclos & Bransford, in press; Leron, 1985; Watt, 1985). Furthermore, several authors argue that experiences with Logo will not develop generalizable skills of problem solving unless instructors provide some degree of structure and prompt students to reflect on their problem solving activities as they proceed with programming (e.g., Bransford, Clayton & Franks, 1983; Delclos et al.; in press; Pea & Kurland, 1983). Some authors describe their approach to teaching Logo as involving a very unstructured, "discovery" method yet, based on the "procedures" section of their article, appear to use a very structured approach (e.g., Clements and Gullo, 1984). It seems clear that more attention needs to be paid to the instructional context within which Logo programming occurs.

Logo is not the only example of a technology-based program that may vary in effectiveness as a function of the teaching context. For example, simulations such as Oregon Trail are often touted as teaching "decision making". Do people who work with these simulations spontaneously learn to make well-motivated decisions? When students simply use the programs without receiving appropriate instruction in decision-making, they can easily engage in haphazard, trial and error behavior (e.g., Bransford, Stein, Delclos & Littlefield, 1985).

The instructional context may be important not only for programs that are viewed as developing higher order skills. It may also improve various programs that seem to involve low order drill. For example, one frequently sees criticisms of programs that provide only "drill and practice". Are such learning situations necessarily limited to the development of "lower order" skills? Several authors argue that drill and practice programs can be transformed into problem solving situations. Thus, when playing mathematical arcade games (e.g., one may have to add numbers in order to get something to happen in the program), students can be prompted to notice and change ineffective strategies such as counting on their fingers or failing to practice systematically on the types of math problems that are causing them difficulty (Hasselbring & Goin, in preparation).

Overall, the preceding examples suggest that technology related activities will vary in effectiveness as a function of the instructional context that surrounds them (see also Pogrow, 1985). These observations emphasize the need for a theoretical framework that can guide decisions about ways that technology might be most effectively used.

## The Concept of Havens

The major purpose of this paper is to explore the concept of idealized learning environments (we shall call them Havens) that facilitate learning.

The ultimate goal of a theory of Havens is to permit evaluations of the degree to which particular types of instructional practices deviate from the ideal. We assume that Havens are not identical to computer-based microworlds because the latter are neither necessary nor sufficient for facilitating learning. Thus, some computer-based microworlds are more Haven-like than others. In addition, the concept of microworlds is broader than the concept of microcomputerworlds. Effective instruction often involves the creation of microworlds that are not computer based (e.g., Burton, Brown and Fischer, 1984).

Our initial explorations of factors that contribute to Havens for learning will involve analyses of children's natural learning environments. Like Papert (1980), we are impressed with the speed and ease with which children acquire new skills and knowledge and would like to understand these processes in more detail. Nevertheless, our analyses of the conditions necessary for children's success often differ from Papert's. For example, Papert (1980) places heavy emphasis on the importance of Piagetian ideas such as active discovery learning, where the primary focus is on the individual child and his or her approaches to various problems. We agree that active attempts to learn are important, but we place equal emphasis on the social contexts for learning that are created by parents, siblings, teachers and peers (e.g., Brown, Bransford, Ferrara & Campione, 1984; Cole and Scribner, 1985; Feuerstein, 1979; Vygotsky, 1978).

In the discussion that follows we emphasize differences between everyday learning environments and the formal educational environments that are characteristic of schools. One of our goals is to ask whether some of the advantages of everyday learning can be incorporated into formal education through the use of technologically created Havens. A second goal is to ask whether, given effective uses of technology, even everyday learning environments can be improved.

Two Views About Children's Learning

Several investigators have argued that there are two conflicting views about children as learners (e.g., Bransford and Heldmeyer, 1983). One is that children are universal novices who consistently perform more poorly than adults. When tested in typical laboratory tasks, for example, children are less likely to remember information (e.g., Kail and Segal, 1977), to comprehend and communicate effectively (e.g., Chapman, 1978; Chomsky, 1969; Glucksberg, Krauss and Higgins, 1975); to solve problems (e.g., Inhelder and Piaget, 1958) and to accurately predict their own abilities to perform various tasks (e.g., Flavell and Wellman, 1977). There are several reasons why younger or less mature learners would be expected to perform more poorly than more mature learners. First, younger learners have acquired less knowledge than older learners (e.g. Chi, 1978; Gelman, 1978) and hence have fewer and less well organized knowledge structures for assimilating information. Second, younger learners are less likely to know and use sophisticated strategies (e.g. Brown, 1979; Flavell, Beach and Chinsky, 1966; Ornstein and Naus, 1978). Some investigators also argue that younger children's working memory is more limited, although the degree to which this is a limitation of "actual" versus "functional" memory is still a matter for debate (e.g., Case, 1974; Chi, 1976). Overall, younger children seem to have a number of disadvantages that can hurt their performance in a variety of domains.

In contrast to the proceeding position is one that views children as exceptionally effective learners. Adults often marvel at the ease with which children acquire concepts, language, motor skills, spatial skills, social skills and so forth. Adults often wish that they could learn as enthusiastically, effectively and seemingly effortlessly as they did when they were young. Bransford and Heldmeyer (1983) emphasize the following:

> ...if we hold this view of "children as exceptional learners" in conjunction with the "child as universal novice" view...we are forced to acknowledge that children are amazingly effective learners despite their lack of knowledge, despite their lack of sophisticated strategies and despite possible limitations on their working memory. How can children be such successful learners in the face of such disadvantages?

Note that assumptions about children's effectiveness as learners generally stem from their performance while learning in everyday contexts rather than from their performance in laboratory tasks. Children's abilities to learn therefore seem to be closely tied to the conditions under which their learning takes place. Important aspects of these conditions are discussed below.

## Learning in Context

One of the advantages of everyday learning is that it usually takes place in the context of meaningful, ongoing activities. Children are therefore likely to receive feedback from the consequences of their actions, and they are able to make use of contextual cues when attempting to understand what others mean. Excellent illustrations of the importance of contextual cues are provided in Chapman's (1978) discussion of children's comprehension strategies. She notes that parents of one-year-old children frequently report that their children understand everything that is said to them. Furthermore, observations of children's performance in natural language settings provide support for such beliefs.

Nevertheless, there is a great deal of information that these children really do not understand.

One example discussed by Chapman involves Lewis and Freedle's (1973) analysis of the comprehension abilities of a 13 month old child. When handed an apple while she was in her high chair and told "Eat the apple", the child bit it. When handed an apple while playing in her playpen and told "Throw the apple", the child threw it. Lewis and Freedle performed an experiment in order to test whether the child really understood words such as "eat" and "throw". They handed the child an apple while she was in her high chair and asked her to "throw the apple". The child bit it. Later, when the child was in her playpen she was handed an apple and told "eat the apple". She threw it. As Chapman (1978) notes, the child's strategy was basically to assume that she should "do what you usually do in this situation". This is a very sound strategy that frequently is correct.

Note that, in everyday settings, young children have rich opportunities for learning because they can use context to figure out what someone must mean by various sentence structures and words. Unless she was being tested by tricky experimenters, for example, the child discussed above could determine the general meanings of "apple", "eat" and "throw". Similarly, if a mother says "Get your shirt" while pointing to the only loose object (a shirt) on the rug, the child begins to understand the meaning of "get" and "shirt". Chapman (1978) emphasizes that language acquisition cannot take place in the absence of shared social and situational contexts because the latter provide information about the meanings of words and sentence structures. In MacNamara's (1972) terms, the child "...uses meaning as a clue to language rather than language as a clue to meaning". The child who is asked to learn out of context often has little basis for inferring the meanings that speakers intend.

The ability to use contextual information as a cue to language is important not only for young children. It is also important for older children who may not understand all the words used by adults. For example, a statement such as "They sawed the bics to make a vac" provides very little information about the meaning of "bics" and "vac". As will be discussed later, however, in certain contexts this statement can produce new learning because context provides many fewer degrees of freedom about what "bics" and "vac" might mean. In an analogous manner, students who have the advantage of a context for interpreting relatively novel (for them) words such as " variability", "maneuver" and so forth should have a chance to learn from the instruction that they receive.

## Context and Elaboration

Clearly, context can provide information beyond what is necessary to understand specific concepts or lexical items. For example, it can also provide information necessary to understand the significance of utterances even if they contain familiar words. The psychologist Karl Buhler (cf. Blumenthal, 1970) noted long ago that an utterance such as "five" can have very different meanings depending on the context in which it is uttered (e.g., it might mean "I need five more seconds, hours, days", "There are five of us here", "The show comes on at five" etc.). When "five" is uttered out of context it is extremely difficult to understand the significance of the message even though one knows what the word "five" means. Peoples' comprehension of the significance of messages is related to their abilities to use relevant knowledge to elaborate what they hear, see or read (e.g., Anderson, 1983; Anderson & Reder, 1978; Stein & Bransford, 1979).

Context also has powerful effects on one's interpretation of relations among statements. Imagine, for example, that one hears "The floor is dirty. Sally is using the mop". The interpretation of these statements differs greatly depending on whether the floor is getting dirtier or cleaner as the mopping continues. In one case the interpretation is synonymous with "The floor was dirty because Sally used the mop"; in the other case it is consistent with "The floor was dirty so Sally used the mop".

Disadvantages of Learning in Context

A potential drawback to learning in context involves the problem of transfer. A number of researchers have compared the effects of informal, in context learning with that of formal, school-based learning (e.g., Cole and Scribner, 1975). A potential disadvantage of informal learning is that paticular concepts or procedures are often "welded" to their initial contexts of application and hence are less likely to be used in new contexts. It is important to note, however, that data concerning the disadvantages of learning in context usually involve teachers or mediators who learned in natural contexts rather than in formal educational settings. In short, there are confounds between where people were taught (in everyday contexts versus in formal educational settings) and how they were taught. Research by Nitsch (1978; see also Bransford, 1979) illustrates that the ability to learn concepts in particular contexts facilitates the speed of initial learning and that, with appropriate instruction, these context-specific concepts can be readily applied in new domains. The issue of learning and transfer is discussed later in more detail.

## The Role of Mediators

Implicit in our discussion of learning in context was the fact that parents, friends and peers play an extremely important role in cognitive development (e.g., Feuerstein, 1979; Vygotsky, 1978). Their role is not simply to act as stimuli who provide words, sentences and actions to be modeled by children. Instead, they act as mediators who provide structure to the experiences of the child. For example, mediators arrange the environment so that children will encounter certain experiences (e.g., toys, books); they help children separate relevant from irrelevant information ("you can eat on this plate even though it is blue rather than red"); they prompt children to anticipate events (e.g., "After we get up from our nap we will do what?") and they help children connect various parts of their experiences ("This story mentions a duck. Didn't we see a duck yesterday in the park?"). In addition, effective mediators monitor the performance of their children so that they can encourage as much independent performance as possible yet provide help (scaffolding) when it is necessary. In Vygotsky's (1978) terminology, effective mediators are sensitive to their child's "zone of proximal development"--the zone where children can perform with prompting in ways that they could not perform without prompting. This sensitivity to the zone of proximal development is assumed to be one of the major factors responsible for children's abilities to learn (e.g., Brown, Bransford, Ferrara and Campione, 1983; Vygotsky, 1978).

The roles played by mediators can be clarified by considering our earlier discussion of the girl who bit or threw apples depending on whether she was in her high chair or play pen. The major goal of the child's parents was not to test whether she really knew the meanings of "eat" and "throw"; instead, they wanted to communicate with their child. They therefore made statements that were appropriate to the context and, by doing so, gave the child the chance to figure out what various words mean.

Snow (1977) provides another example of how parents behave in ways that help young children learn important information. Parents of very young children often provide information about the nature of conversations by pausing in places were the child's responses should be and by accepting almost anything (e.g., a burp or a hand movement) as part of the infant's contribution to the conversation. As infants become older and more competent as conversationalists, the parents narrow their criteria for what counts as an acceptable response. Additional examples of the role of mediators are provided by Greenfield (1984) and by Rogoff and Gardner (1984). In each of these examples, parents are helped in their ability to provide appropriate interventions or "scaffolds" because of the child's active participation. This behavior provides an important index of the degree to which the child has understood. For example, parents can frequently tell by children's actions whether they have understood a statement or request.

It is instructive to contrast the preceding situation to the plight of the school teacher who frequently has to work with a number of students. When providing a lesson, for example, the teacher must usually rely only on general actions such as nods and "looks of understanding" in order to gauge the appropriateness of the instruction. Under these conditions it is very difficult to assess each student's level of comprehension and to modify the instruction in order to meet various needs.

Recreating Shared Contexts

In the preceding discussions we focused on in vivo learning in the sense that mediators helped children perform tasks that were relevant to their current environment. Another aspect of learning involves the recreation of contexts that one has shared with a child. For example, Rogoff and Gardner (1984) discuss an experiment where mothers were asked to help their 6 to 9 year old children perform a memory task involving objects that are usually found in the kitchen. Many of the mothers did not simply rely on the context of the experimental room (which was designed to look like an actual kitchen). Instead, they attempted to supplement this environment by helping the child recreate more familiar situations. One mother started by saying "Okay, now we just got home from the store, okay?" Another began with "Okay, now, this is going to be a very organized kitchen...just like ours, right?" Parents' instructions frequently followed the form of imagining a situation that the child presumably knew and using it as a context for performing various tasks.

It seems clear that there are many other instances where children are helped to learn because mediators prompt them to recreate familiar environments. The present authors frequently find themselves referring to well-known situations in order to explain the meaning and importance of new concepts to our children. For example, when one of our children took Logo programming, we found that it provided a useful context for discussion even when no computers were available. Similarly, we find that simple concepts of problem solving and the use of strategies can be readily understood by four year old children when the concepts are introduced with reference to movies such as The Wizard of Oz, Swiss Family Robinson and so forth.

In order to be effective, mediators need to be aware of various experiences that the child has had that can provide a context for new learning. This is relatively easy for parents who have shared a great number of experiences with their children. For a teacher, however, it can be very difficult to know which sets of experiences will provide support for each child's learning. The task becomes even more difficult when children come from cultural backgrounds that differ from those of the teacher. Under these conditions, children may have special difficulties in their attempts to learn because they lack contextual support.

Knowledge as Tools

We noted earlier that the opportunity to learn in context should not necessarily interfere with transfer. Instead, the degree of transfer should depend on the type of mediation that people receive. A number of theorists argue that it is particularly important for people to understand how concepts and procedures can function as tools that enable them to solve a variety of problems (e.g., Bransford & Stein, 1984; Dewey, 1963; Hanson, 1970; Vygotsky, 1978). Bacon (1620) emphasized this idea long ago when he discussed the importance of mental "helps" or tools:

> The unassisted hand and the understanding left to itself possess but little power. Effects are produced by means of instruments and helps, which the understanding requires no less than the hand.

The idea of powerful sets of "helps" or tools for enhancing general problem solving seems to be a very important component of a Haven for learning. Based on our experiences, few students view their courses from this perspective. For example, we have asked a number of college students majoring in education or arts and science to explain why logarithms are useful. In what ways do they make it easier to solve various problems? Despite remembering something about logarithms, the vast majority of the students were surprised when told that logarithms represent an important invention that greatly simplifies problem solving. They had never been helped to understand logarithms in the way illustrated by the following quotation from the English Mathematician Henry Briggs (1624):

> Logarithms are numbers invented for the more easy working of questions in arithmetic and geometry. By them all troublesome multiplications are avoided and performed only by addition....In a word, all questions not only in arithmetic and geometry but in astronomy also are thereby most plainly and easily answered.

We have encountered many additional examples of situations where students have memorized factual and procedural information with very little appreciation of how they simplify problem solving. For example, what would happen if we used only one standard of length measurement such as inches rather than use a number of them such as feet, yards and miles? What would happen if there were no concept of multiplication and division and we could only add and subtract? Some children assume that the elimination of a variety of standards and computational procedures would make life easier because less learning would be necessary, and to some extent they are correct. Nevertheless, they need to be helped to see that such inventions are extremely useful. For example, it would be very cumbersome to express all distances in inches and to have to add rather than to use multiplication as a short cut for computing answers. In Bacon's terminology, these inventions are important mental "helps" or tools.

In everyday learning, the tool function of information is generally apparent. For example, when a parent teaches a child about a physical tool, he or she provides information about function as well as structure. Implicitly, at least, the child understands how a tool makes it easier to solve various problems that one may face (e.g., a spoon helps us solve the problem of eating soup and other foods in liquid form). Similarly, a person who acquires conceptual tools understands at least some of the problems that the tools make it easier to solve.

One advantage of understanding the tool function of concepts and inventions is that people comprehend their value and therefore are more motivated to learn. This is especially true when people encounter naturally occuring problems that "create the need" for new information and inventions. Vygotsky (1878) illustrates how the creation of needs can affect the acquisition of new information. Similarly, one of Papert's arguments for the advantage of Logo programming environments is that, during the course of attempts to achieve self-initiated programming goals, students will encounter problems that enable them to understand the value of new concepts and procedures. For example, in Logo classes children often have difficulty drawing designs because they did not know how many degrees to turn in order to draw a square corner, a triangle and so forth. When inventions such as protractors are introduced, the students can quickly see how these devices enable them to solve problems that they were confronting. In contrast, when concepts and inventions are introduced out of context, they are frequently viewed as "something complicated to be learned" rather than as tools that simplify one's life (e.g., Bransford & Stein, 1984; Vygotsky, 1978).

## Conceptual Tools and Transfer

People's abilities to understand the need for new tools seems to involve more than an increase in motivation to learn about them. People are also more likely to understand the conditions under which the tools are useful and hence should be more likely to access them when needed. Many inabilities to solve problems stem from failures to access relevant information that was previously acquired (e.g., Bransford & Nitsch, 1978; Brown & Campione, 1978).

Some striking examples of failures to access relevant information are illustrated in several recent studies involving college students (e.g., Gick & Holyoak, 1980; Perfetto, Bransford & Franks, 1983). In these studies, students were presented with information that was clearly relevant to the solution of various problems and were then presented with the problems. Unless explicitly prompted to use the relevant information, students failed to solve the problems they received.

Consider some examples from the Perfetto et al. study (1983). Students were presented with a series of "insight" problems such as the following:

> Uriah Fuller, the famous Israeli superpsychic, can tell you the score of any baseball game before the game starts. What is his secret?
>
> A man living in a small town in the U.S. married twenty different women in the same town. All are still living and he has never divorced one of them. Yet, he has broken no law. Can you explain?

Most college students have difficulty answering these question unless provided with hints or clues. Prior to solving the problems, some students were given clue information that was obviously relevant to each problem's solution. Thus, these students first received statements such as "Before it starts the score of any game is 0 to 0"; "A minister marries several people each week." The students were then presented with the problems and explicitly prompted to use the clue information (which is not stored in memory) to solve them: Their problem solving performance was excellent. Other students were first presented with the clues and then given the problems but they were not explicitly prompted to use the clues for problem solution. Their problem solving performance was very poor; in fact, it was no better than that of baseline students who never received any clues.

Failures to access relevant information are often assumed to be due to breakdowns in metacognitive processes. This concept is, however, ambiguous (see Brown et al., 1983). For example, it seems clear that general strategies such as "search for similar problems that you have encountered" are relatively weak (e.g., Newell, 1980). The success of one's ability to access relevant information seems to depend heavily on the way in which it was learned originally. As an illustration, assume that students are without a calculator or computer and must multiply a number of pairs of large numbers. Unless they had previously learned that logarithms enable one to substitute simple additions for difficult multiplications, it is highly unlikely that they would think of using them in this situation. Similarly, people who learn how the structural features of camels enable them to survive desert sandstorms are more likely to use camels as a model for thinking about the problem of helping people survive in deserts (Bransford, 1984). If only facts or properties of logarithims or camels are taught, exclusive of their applications, access of these concepts in order to apply them to new problems is not facilitated.

## Summary of Children's Learning

To summarize, we have argued that it is important to explore the concept of Havens--of idealized learning environments. As an initial step in this direction we focused on young children's remarkable abilities to learn despite a number of disadvantages such as lack of knowledge, lack of sophisticated learning strategies and possible limitations on working memory. The efficiency of children's learning seems to stem, in part, from the advantages of learning in context. Furthermore, children are helped considerably by the presence of mediators who arrange environmental conditions and provide feedback and instruction that is uniquely suited to the performance level of the child. Mediators also help children recreate mutually familiar contexts so that discussion and instruction can more readily take place. In addition, they help children transform facts and procedures into useful conceptual tools.

In contrast to the advantages of everyday learning in childhood, children in formal educational settings are often forced to learn out of context. Teachers may try to provide contexts through pictures and verbal descriptions, but they often have little knowledge of the types of experiences that each child could use in order to better understand the intended instruction. Furthermore, the contexts provided are frequently unrelated to one another rather than integrated into overall themes such as "What we do on Saturdays?" or "What happened during our last camping trip?". Through the use of technology to make instruction more similar to the Havens normally available to children, it should be possible to create integrated contexts that permit effective mediation.

## Overview of the Experiments

The experiments discussed below are designed to (a) illustrate and (b) evaluate some procedures for creating Havens for learning. We use video tapes and computer-controlled videodiscs to create meaningful environments that can be shared by students and mediators, and we compare the effects of learning in these Haven-like environments with the effects of environments that are often found in schools. We then discuss how more sophisticated use of computer-controlled technology can be used to create Havens that are even more ideal.

The video segments that we have used involve popular films such as Swiss Family Robinson, Raiders of the Lost Ark and Smokey and the Bandit. One reason for using existing films to create contexts for teaching is that this procedure eliminates the costs of producing high-quality video--costs which average approximately $1,000 a minute. In addition, the films are highly motivating to watch. Furthermore, since the films do not include instructional segments in them, there is much more opportunity to use them flexibly than is usually the case with typical educational films. The ability to use computer controlled access to any segment of a videodisc makes the opportunities for instruction much richer than is possible in typical uses of films.

The purpose of the videos is to provide a context for mediation. Students who view the video segments in the absence of a mediator are entertained, but they miss most of the opportunities for learning that the video provides. For example, we have shown segments of Smokey and the Bandit to a number of college students. None of them spontaneously noticed the richness of problem solving that takes place in the film. Once students are provided with some background and direction, they begin to notice that the film is full of problems and strategies and that it includes a number of "natural word problems" such as the average speed the actors must drive in order to travel from Georgia to TexArkana and back to Georgia in 20 hours. The segment becomes especially rich when students are prompted to evaluate the accuracy of the film. For example, can a truck really hold as much cargo as the actors need? Is their estimate of the average speed needed for the trip accurate, especially since they would probably have to stop for fuel? Is it reasonable to use the actors' strategies for switching channels on their CB so that the police cannot track them and for keeping a running record of how much they are on schedule?

We have also worked with segments of Swiss Family Robinson. This film provides a rich problem-solving context since it involves a shipwreck, attempts to explore an island and so forth. For example, during the first 25 minutes of the film one sees the shipwreck, the construction of a raft and a journey to shore, the construction of a makeshift shelter, a trip back to the ship to get additional materials, a foray with pirates and a trip back to the shore.

The first 14 minutes of Raiders of the Lost Ark also provides an excellent context for learning. For example, at one point in the film Indiana Jones wants to fill a bag with sand so that it weighs the same as a golden idol. Assuming that the idol is solid gold, how reasonable is it to suppose that it weighs about the same as a small bag of sand?

This question can be addressed at a number of different levels of complexity. For example, students in a high school science class might be helped to calculate the mass of the idol based on estimates that could be approximated from the movie and on information about the density of gold. Discussions could then involve questions about other metals (e.g., lead) and the mass they would have. The use of the bag of sand as an equal mass could then be investigated. An approximation of the volume of sand needed to equal the mass of the idol can be calculated based upon the density of silicon dioxide. Our calculations indicate that the idol would have to have a mass of 38 kilograms, and that the volume of sand would have to be over 15,000 cubic centimeters. If the idol were really this heavy, it is also instructive to observe other scenes in the movie where it is carried and thrown with almost no effort. A number of other aspects of just the first 14 minutes of the movie provide a context for a host of additional problems. For example, the explorers taste the poison on an arrow to see if it is fresh. Is this possible? And where did the natives get the poison and how does it affect the body?

At another point Indiana Jones jumps across a pit. What cues can be used to estimate the length of the pit? Given this information, could a human possibly jump across it (for example, what is the world record in the running long jump?). In addition, if the latter information is not available or needs to be calculated for a particular individual, how does one do so? This problem provides a context for discussing experimentation, averages, variability in performance and so forth.

Indiana Jones also has a number of spiders on his back after he enters a cave. Are these supposed to be dangerous from the perspective of the film? (yes). Would the film makers actually put dangerous spiders on their star actor? (probably not). What kinds of spiders are these (a form of tarantula). Do they live in South America? In caves? Did they spin the giant webs in the caves?

At another point in the adventure Indiana and his cohort use torches to light their way. Why did they not use flashlights? At the beginning of the film the date is given as 1936. Was there electricity at this time? (yes). Were there batteries at this time, and how portable were they? The concept of "portable electricity" and how it is made become salient here. In addition, one can ask about the variables that should be considered in order to determine the number of torches to take on a trip (e.g., how long do they last, how long is the trip, how many are needed at once, etc.). The preceding examples occur during the first 14 minutes of the Raiders film. There are many different situations that occur during these 14 minutes--so many that, after watching the segment as many as 50 times, we keep noticing new questions that are relevant for educational purposes. Furthermore, there are many more scenes in this film and there are many other films as well.

Experiment 1

The purpose of Experiment 1 was to assess some of the claims made earlier about advantages of learning in semantically rich environments. For example, we argued that rich contexts enable people to infer the meanings of unfamiliar concepts, make elaborations, and interrelate ideas and concepts that otherwise might seem unrelated. We also argued that these advantages are important not only for children but for adults as well.

Subjects. Subjects were twenty-six, undergraduate college students at Peabody College of Vanderbilt University. Students received extra credit for their participation in the experiment.

Materials. The video segment used to create a context for the experimental group was the first 25 minutes of Swiss Family Robinson. As mentioned previously, this segment of the film involves many scenes where the film characters are involved in problem solving situations.

Four sets of test items were used in the experiment. The first consisted of a set of 10 difficult-to-comprehend sentences such as "The rocks were helpful because the cloth had ripped", " The pig was safe because the barrels were tied". One has to make a number of inferences in order to comprehend such statements. For example, the first becomes more comprehensible if one assumes that it refers to a ship whose sails were torn and would capsize if it did not get wedged between some rocks (this happens in Swiss Family Robinson). The second statement makes sense if one relates it to the scene where barrels are tied to a pig in order to help it float while travelling from the ship to the shore.

Statements similar in form to those used in the present experiment have been used in other studies that explored various effects of previously acquired knowledge on comprehension and retention (e.g. Bransford & McCarrell, 1984; Auble & Franks, 1978; Franks, Bransford & Auble, 1982). However, in these other studies, specific contextual information was always presented for each individual sentence. For example, the cue "bagpipes" was presented for "The notes were sour because the seam split". In the present study we did not supply specific cues for individual sentences. Instead we asked whether, given a 20 minute segment of film, students could generate the specific information necessary to make the statements make sense.

A second set of test items assessed students' abilities to fill in the blanks in texts and to infer the meaning of nonsense words. For example, students were asked to decipher statements such as "The Lel was in trouble so they needed to reach the Geck. They therefore sawed some Becs to make a Zim". A number of authors have studied peoples' abilities to infer the meanings of new or unfamiliar words as a function of verbal context (e.g., Werner, 1950; Sternberg & Powell, 1983). We asked whether a verbal context in conjunction with video can facilitate the ability to predict and infer meanings. As noted earlier in this paper, children seem to use contextual information in order to learn the meaning of new statements and words (e.g., Chapman, 1978; McNamara, 1972).

A third set of test items assessed students' abilities to generate inferences that provide coherence to a message. For example, students were asked to interpret paired statements such as "The shore was barely visible. He picked up the saw", "The cannonballs were getting closer. He thought about the flag". The ability to generate sentence-connecting inferences is necessary in order to comprehend (e.g., Haviland & Clark, 1974; Kintsch, 1976; Trabasso, Stein & Glenn, 1977).

The fourth set of test items consisted of a list of 30 topics such as telescopes, diseases, heroism vs. cowardice, why wood floats, sharks, brains over brawn, maritime law, etc. Students were asked to read each topic and rate the degree to which it might provide a useful lesson for fifth graders. Following the rating test they received a surprise, free recall test over the 30 topics. The purpose of the recall test was to assess the effects of the film context which, because of its organizing properties, should facilitate retrieval (e.g., Mandler, 1967). As noted in the earlier discussion, the availability of an integrated context should facilitate students' abilities to remember and summarize what they learned in school.

Procedure. The two groups in the experiment consisted of a film viewing group and a non-viewing group. The film viewing group saw the 25 minute segment of Swiss Family Robinson mentioned above before completing the assessment instruments. The non-viewing group saw no film before completing the instruments. Fourteen subjects were in the viewing group and 12 were in the non-viewing group.

Results. Descriptive statistics and *t*-tests for the various instruments across the two groups are presented in Table 1.

-Insert Tabe 1 here-

As can be seen from Table 1 there were substantial differences between the groups on all of the measures, with the film viewing group having higher scores in each case. All of the *t*-test results are significantly different at $p < .001$ except the number of concepts remembered task (fourth task), which had a probability level of $p < .05$ for a one-tailed test.

Discussion. The results of Experiment 1 illustrate that video segments can provide a number of advantages that are similar to those available to young children. First, college students who had seen the video segment were better able to understand the meaning of difficult-to-comprehend sentences than were students who had not seen the video (see the first column in Table 1). These results suggest that the video context permitted inferences about the referents of various statements and about relations among these referents. For example, in order to comprehend a statement such as "The flag worked because the consequences were dire" one needs to understand the type of flag used (a signal flag) and its message (it signalled the presence of black plague). One also must understand "work" and "consequences" in the sense of "the use of the flag scared away the Pirates since they were frightened of the consequences; namely, catching the black plague."

Data illustrating the effects of context on language comprehension have usually involved very specific types of information that were supplied just prior to or just after individual statements (e.g., Bransford and McCarrell, 1974; Auble and Franks, 1980). In the present experiment, students were able to make use of contextual information that was distributed across 25 minutes of film.

A second feature of Experiment 1 is that college students who had seen the video segment were much better able to determine the intended meaning of nonsense words than were students who had not seen the video (see the second column of Table 1). For example, the video helped students interpret the meaning of "The Lel was in trouble so they needed to reach the Gek. They therefore sawed some Bics to make a Zim". Of course, nonsense words are rarely used in educational contexts so one might argue that these results are irrelevant. We contend that similar processes are important when students are not, or are only partially, familiar with concepts used by teachers in school. This issue is explored more fully in Experiment 3, below.

A third pattern of results from Experiment 1 is that students who had seen the video segment were much more consistent in the inferences they made to fill in the gaps in messages than were students in the non-video group. All students received sets of sentences such as "The shore was barely visible. He picked up the saw" and were asked to explain the relationship between the sentences. Students who had seen the video were very consistent in their answers. For example, for the preceding sentences they stated that the saw was used to make a raft for getting to shore.

The data reported in the third column in Table 1 reflect the degree to which students made inferences that were consistent with information from the movie. Students in the no-video group were usually able to make some type of inference, but it was often hard to determine whether their inferences really made sense. Therefore, if their inferences did not reflect the theme of the movie we did not score them as correct. We decided to score the data in this manner because it is usually important to teachers that students' inferences conform to the intended theme of a lesson. An alternate measure would be to assess the time necessary to make various inferences. It is our impression that students without a video context would take more time regardless of whether their inferences were consistent with the survival theme illustrated in Swiss Family Robinson. Furthermore, we expect that, for younger children, video context will often be necessary in order for them to generate any inference. This latter issue is also explored in Experiment 3, below.

The fourth set of results found in Experiment 1 illustrates how a common theme can facilitate remembering (see the fourth column in Table 1). Students who had seen the video were better able to recall a set of topics for potential lessons than were those in the no-video group. Since the video can provide a context for retrieval, we suspect that the recall differences between the video and no-video group would become larger as a function of greater time lags between acquisiton and test.

Overall, the results of Experiment 1 provide strong support for advantages of using technology to create some of the Haven-like environments that are available during childhood. The data show clearly that video-based contexts can help college students understand difficult-to-comprehend statements, determine the meaning of nonsense words, fill in the gaps in messages and recall a number of seemingly-unrelated topics. Of course, the materials used in Experiment 1 were artificial. We used these materials because they are especially useful for revealing differences in inference processes. In the next experiment we explore how similar processes affect the comprehension of materials that are more similar to those normally found in schools.

Experiment 2

The purpose of Experiment 2 was to provide more explicit information about the effects of video context on students' elaborations of information. Experiment 1 used materials that forced students to make inferences in order to comprehend them--materials such as "The rocks were important because the sail ripped" and "They sawed the Becs to make a Zem." In Experiment 2 we used information that was comprehensible even without a context and we explored how students' understanding of the significance of the information was influenced by context. Experiment 2 used segments from Raiders of the Lost Ark rather than from Swiss Family Robinson because

"Raiders" was available on interactive videodisc and hence individual scenes could be presented more efficiently. Nevertheless, it seems clear that analogous experiments could be conducted with almost any film.

Consider statements such as "Some poisons are so powerful that even a small taste would result in death", "A beam of light that shines through a hole in a cave will disappear at night", "A solid gold statue the size of a 1/2 gallon milk carton would weigh approximately 80 pounds". These statements can be understood in the absence of explicit contextual support. Nevertheless, the same statements seem to generate more elaborations when comprehended from the perspective of a relevant context. For example, in Raiders of the Lost Ark some of the men taste a poison arrow in order to see if it is fresh. When the statement about deadly poisons is heard in this context it becomes clear that, if the poison had been extremely deadly, the men might have died. Similarly, the statement about light shining through a hole in the cave seems to be understood and elaborated at a deeper level of significance when comprehended in the context of a trap in a cave that is activated when Indiana Jones breaks the beam of light with his hand. Since the light comes from sunlight, the trap should be set off every night. The statement about the weight of gold has a number of implications, including the fact that the bag of sand used by Indiana Jones was much too light and that he would be unable to carry the idol with ease.

Experiment 2 was designed to measure elaborations in two different ways. First, we asked students to rate the interest value of various statements and measured whether interest varied as a function of video context. Second, we asked students to think aloud while reading statements that occured either in or out of context, and we recorded their elaborations as they thought aloud. As noted in the introduction to this paper, elaborations are important because they can facilitate comprehension and retention plus increase the effectiveness of retrieval cues (e.g., Anderson & Reder, 1979; Stein & Bransford, 1979; Bransford et al., 1983).

Subjects. The subjects of the experiment were undergraduates attending Peabody College of Vanderbilt University. Subjects were volunteers and received extra credit for their participation. Eight students were randomly assigned to experimental and control groups for the interest rating task. Four additional students were assigned to the "think aloud" group.

Materials. Two different sets of materials were prepared for the first part of the experiment. The first item was a sheet that had information about the concept of density. This was in the form of a definition and a table of densities for three elements (water, gold, and lead), with an approximate density for sand. The equivalence formula for pounds and grams was also given. At the bottom of this sheet was the question "How interesting was this information to read?" with a seven-point Likert scale ranging from "Not at all" to "A great deal".

The second sheet contained seven unrelated sentence items that were preceded by the statement "How important and interesting are the following statements? Please rate them according to the following scale." with the same rating scale as the previous instrument. Examples of the seven items are "Some poisons are so powerful that even a small taste would result in death." and "There were no small, powerful batteries in 1936, so torches were often used for light." All of the items could be related to the first 14 minute segment of Raiders of the Lost Ark.

Procedure. All subjects in the ratings condition were first given the density information sheet, were asked to read it, and were then asked to complete the interest rating scale at the bottom of the page. They were given two minutes to complete this task. Subjects were then given the list of statements and asked to rate each statement on interest.

After making the ratings, subjects in the control group viewed the opening, 14 minute sequence of a film that was unrelated to the written materials--the film Swiss Family Robinson. They then repeated the density information and unrelated sentence tasks.

The experimental group viewed the opening 14 minute sequence of Raiders of the Lost Ark. The experimenter next showed the segment from the film where Indiana Jones is using a bag of sand to substitute for the golden idol. Subjects were to keep in mind two questions: (1) "Is this a resonable assumption for Indiana to make?", and (2) "How can we estimate, without a golden idol, how much both the ideal and the sand weigh?". Subjects were then asked to again complete the density information sheets.

Subjects were then shown seven video segments that corresponded to the seven unrelated statements in the final instrument. They were told to keep the segments in mind and were then asked to complete the unrelated sentences instrument.

Both the experimental and control groups were asked if the movie influenced their ratings of the sentences. They were also asked to provide examples of any influence that the movie had on their second performance. These examples were written on the back of the final instrument.

Students in the "think aloud" group received the same pre- and post-test materials as did those in the ratings group. However, students in the think aloud group were asked to say what they were thinking as they read about density and about the individual sentences.

-Insert Table 2 here-

Results. Table 2 summarizes the descriptive statistics for the students' ratings of how interesting the density information and the unrelated sentences were across pre- and post-tests. As can be seen from Table 2, the ratings for the experimental group increased while those for the control group did not change. A mixed model ANOVA revealed a significant main effect for the within groups factor (pre vs. post) ($F$=4.95, $p$<0.04) and a significant interaction ($F$=5.57, $p$<0.03), indicating that the appropriate film segment did indeed affect interest. The interest ratings in the density information did not reach significance for either the within subjects' factor ($F$=3.48, $p$=0.08) or the interaction ($F$=1.07, $p$=0.32) although the trend in the data is in the hypothesized direction.

Comments from students about the influence of the movie on their ratings showed a pattern of increased understanding of the importance of the sentences within the context of the movie. Six of the eight students in the experimental group spontaneously made definite, positive statements about the effect of the movie on changing their interest in the statements. Some responses were, "Seeing this movie effected my interest rating. I could apply and relate these questions to something so I became more interested in them" and "It [the movie] made them more interesting and made me think more about the statements. For example, did they cock the gun by hand? The light trap would not be effective at night."

Comments by the control students toward the movie took a different direction. Five of the eight students made comments about the movie (Swiss Family Robinson) having a "calming influence" or "The movie put me in a better mood because I liked it ...", indicating that the unrelated film was viewed only as a diversion rather than as a help for obtaining more meaning about the statements.

The "think aloud" group provided additional information about students' perceptions of the significance of the information in the unrelated sentences. As with the experimental group, the students' mean ratings of the unrelated sentences increased from pre-movie to post-movie (mean pre-:3.62 , var.:0.002; mean post-:4.89 , var.:0.29 with a $t$ value of 3.01, $p<0.05$ by a one tailed test).

More revealing than the interest ratings were the comments of the "think aloud" students, both pre- and post-viewing. Before the movie, students generally had neutral comments about the density information and the statements. One subject noted, "The information is just like chemistry class, not very interesting". However, after the video she noted "It [density information] is more interesting now that you have a dramatic situation to apply it to." Subjects especially noted their change in interest for the statement "A solid gold statue the size of a 1/2 gallon milk carton would weigh approximately 80 pounds." One noted, "After seeing the movie that one was a lot more interesting. Indy just tucked it under his arm and ran and tossed it with a lot of ease, so if it was 80 pounds it would have taken a lot more strength." When asked about an overall effect of the movie, all subjects in the "think aloud" group made positive comments about its ability to make things more interesting. One subject made the comment, "The statements became more relevant to each other. They had a purpose."

Discussion. The results of Experiment 2 indicate that identical sets of information were viewed as being more or less interesting depending on the context to which they were related. Students who were given an opportunity to relate statements to relevant aspects of the film Raiders indicated that the film experience increased their interest in the statements. In contrast, students who saw film segments from Swiss Family Robinson indicated that they enjoyed the video but that it did not increase their interest in the statements that they read.

The data involving the interest ratings are consistent with subjects' reports of their elaborations of information. The segment from Raiders provided a context that enabled students to understand the implications of various statements. For example, information about the weight of objects that were solid gold became much more interesting when it was processed in the context of the Raiders of the Lost Ark segment. Students were then better able to understand the significance of the information because they could imagine a host of implications such as "The idol would be very heavy to carry" and "A small bag of sand would be much too light".

The results of Experiment 2 seem to be applicable to a wide range of materials. For example, Bransford and Nitsch (1978) suggest that a statement such as "A pliers can be used as a weight" seems mundane to most people. Similarly, if people are presented with a word such as "bagpipes" they generally read it and ask "so what?" In particular contexts, however, the preceding information can be extremely important. For example, the information about the pliers functioning as a weight frequently prompts insight in people who are trying to solve the Maier (1931) two string problem. Similarly, for people who are trying to understand a statement such as "The notes were sour because the seam split", information about bagpipes provides an "aha" (Bransford and McCarrell, 1974; Auble and Franks, 1978).

It has been argued that differences in the perceived significance of information often create difficulties in educational contexts (e.g., Bransford, Nitsch and Franks, 1977; Bransfora and Nitsch, 1978). In particular, teachers and authors often believe that they are imparting information that should yield significant insights to students whereas, from the students'perspective, the information is often perceived as imparting relatively arbitrary and uninteresting facts. In general, teachers and authors have already experienced a number of problem situations, hence they have a basis for understanding the significance of information. Students frequently lack such a basis. By way of analogy to Experiment 2, teachers have frequently "seen the movie" whereas students have not yet had a chance to do so. The students are therefore at a disadvantage because, even though they can understand basic statements, they are unable to elaborate and hence fail to appreciate implications that their teacher or author assumes.

Overall, the results of Experiment 2 extend the findings of the previous experiment. In Experiment 1 we saw that appropriate video contexts could enable college students to comprehend the meaning of unfamiliar words or concepts and to make inferences that connect events and fill in gaps in messages. The results of Experiment 2 illustrate that video contexts also affect students' understanding of information that is comprehensible without any context. These affects of context are more subtle but they nevertheless seem to be very important. By increasing people's abilities to elaborate the implications of various statements, appropriate contexts can enable students to understand the richness of meanings that their teachers or authors assume.

Experiment 3

Experiments 1 and 2 were conducted with college students in a laboratory setting. In Experiment 3 we worked with 6th graders in an elementary classroom. The purpose of the experiment was to assess whether a video segment could provide a context that facilitated the acquisition of new vocabulary and the comprehension of text. An important feature of the experiment was that a subset of the information to be learned was not simply redundant with the video context. Instead, this information was relevant to the context yet also novel. The use of three groups--video context alone, video plus text, and text alone--permitted an exploration of synergetic relationships between video context and text.

Research in reading suggests that the availability of relevant, contextual information should facilitate comprehension. For example, accepted practice in reading education emphasizes the importance of prediscussion of concepts and background information that are relevant to the selection to be read. Reading instruction using basal readers, the most prevalent form of reading instructional method and materials currently used, requires a procedure that begins with prediscussion. The purpose of the prediscussion is to build required background vocabulary, present a context for the reading selection, and provide a purpose for reading.

Based on her research on reading practices, Durkin (1984) reports that prediscussions are often cursory and omit crucial information. She notes that the lack of prediscussions is often due to teachers' concerns over the time required to prepare for such activities. Similarly, interviews conducted by the investigators with teachers in Nashville suggest that they sometimes give up on the possibility of providing background knowledge appropriate for all children. Since children often range widely in their backgrounds, it is difficult for teachers to target discussion so that it is appropriate for all students. Additionally, some students may have difficulty understanding the prediscussion, or may simply not function or participate well in such an activity. The present experiment used a video segment to provide a background context within which reading took place.

Subjects. Twenty-nine sixth grade, public school students participated in the study. The students were identified by their teacher and by the school principal as performing approximately one to two years below grade level in reading. Students were randomly assigned to one of three experimental groups: (1) movie only (n=10); (2) movie and text (n=9); (3) text only (n=10).

Materials. The film segment used in this experiment was the first 12 minutes of Swiss Family Robinson beginning with the storm and subsequent shipwreck, and ending when the family reaches shore on a raft they had built. Both the movie and movie-text group were shown this film segment. Additionally, a story related to the film segment was written at the students' reading level, and was read by the movie-text and text only groups. The story was 745 words in length, and was divided into two parts (386 and 359 words, respectively). Eleven comprehension questions were asked on each part.

Ten vocabulary items, all concepts relating to the story, were identified: supplies, clutter, reef, mast, abandon, fierce, cooperation, courage, risking, planning. Two vocabulary tests were constructed on these ten words. One required students to generate definitions or examples for the ten concepts. The other was a matching task, where students were to select the appropriate definition for each word from a list.

Additionally, ten words appearing in the text passage were underlined: capsize, ideal, jammed, lifeboat, containers, definitely, maneuver, avoid, knelt, return. Knowledge of these words was tested after the passage was read (or after the film was seen for the movie only group). As before, students were asked to generate meanings or examples for these ten words, and were also asked to match items in a list of definitions with the ten words. These ten words were not taught or discussed, allowing evaluation of whether or not the film context enhanced incidental learning of vocabulary.

Finally, students were asked to discuss a context in which each of three sets of sentences made sense. These were: (1) They saw the shore. He picked up the saw; (2) The rope slipped. The mother's hair was wet; (3) The rocks were dangerous. They needed to leave. As in Experiment 1, these sentence pairs are easily understandable yet they need a relevant context in order to become linked. The first sentence set can be related to the family noticing that the shore is close enough to reach by raft. The father and brothers decide to saw barrels and planks to make a raft. The second set can be related to a point where the mother is being lowered onto the raft by a rope. The rope slips and the mother falls into the ocean. The last set can be related to the fact that the ship was aground on rocks and that it was dangerous for the family to stay on board because the ship could sink at any time.

Procedure. The experiment took place over a three day period. Table 3 presents the activities that took place on each day, by group. The tasks given to students followed a general sequence of (1) vocabulary to test effectiveness of in-film vs. out-of-film contextual presentation; (2) reading the story and answering comprehension questions; (3) vocabulary to test incidental learning; (4) provision of meaningful context for situtation-specific sentences. The following discussion describes the procedures involved in each specific task.

-Insert Table 3 here-

Vocabulary. In order to evaluate the effects of providing a context within which vocabulary is taught and learned, one group of students was taught the ten vocabulary items in a context relating to the story line (movie-text), while another (text only) was not. A control group (movie only) received no vocabulary teaching. Students in the movie-text group viewed the film segment and were then taught the initial set of ten words using the film context. That is, the words were embedded in sentences such as "Cooperation helped the family get to shore." and the teacher made reference to the film when teaching the words ("Remember when the family all helped build the raft? That's an example of cooperation"). Students in the text only group were taught the words in sentences and through discussion that was not directly related to the Swiss Family Robinson context. For example, words were embedded in sentences such as "Cooperation was needed by the baseball team to win the game."

Comprehension. Both the movie-text and text only groups read the text passage after completing the vocabulary tests. After reading the first part of the passage, students answered 11 comprehension questions. They then continued reading the story, after which they answered the remaining 11 comprehension questions. All three groups then completed vocabulary tests on words that had been underlined in the story. These words appeared only in the text. The movie only group thus had no prior exposure to the words and was used as a control.

The final task for all students was to provide a meaningful context for three sentences that were easily understood. Students were read the sentences, and were then asked to write a brief description of a context in which each sentence pair made sense.

Results. A priori, planned comparisons were used to answer the questions of interest. Two sets of contrasts were used, one comparing the movie only and movie-text groups, the other comparing the text only and movie-text groups. Thus, the effect of presenting prior, video-based context was assessed in reference to presenting information only in either visual or in textual form. Table 4 summarizes the results of the ANOVA, using planned comparisons.

-Insert Table 4 here-

Consider first the data for vocabulary instruction. The results of the planned comparisons in the first vocabulary task, where words were taught either in or out of the film context before the text passage was presented, showed no statistically significant difference across the two presentation methods (contrast 2). This result cannot be attributable to a ceiling effect or to the possibility that students may already have known the words since contrast 1, between the group receiving no instruction (movie group) and the group receiving in-context instruction (movie-text), showed a significant difference in favor of the group receiving instruction. Thus, instruction is clearly better than no instruction, but the method of instruction did not make a difference in student performance. This is true across both vocabulary tests: one requiring students to generate meanings, the other requiring students to choose a meaning from a list of possible definitions.

The data for reading comprehension reveal important differences between groups. In particular, there was a significant difference, in favor of the group receiving prior video context, on measures assessing comprehension. Students in the movie-text and text only groups read an identical story. The story was read in two parts, with 11 comprehension questions asked after each part. Results indicate that, for both parts of the story, the group receiving prior video context performed significantly better than either the video only or the text only groups.

An additional analysis was performed to clarify how the video context facilitated text comprehension. One possibility involves the redundancy hypothesis, which assumes that the video segment contained information that was redundant with the text, hence students in the video plus text condition had two sources of information for various questions. Another possibility involves the synergy hypothesis, which assumes that the video segment made textual information more meaningful despite the fact that the video information was not redundant with information in the text.

In order to explore the redundancy and the synergy hypotheses, we analyzed information from the second segment of the story, since much of this segment was written so that items and actions that did not take place in the film were included in the story. For example, the film ended when the family reached shore. The text, however, continued by stating that the family did not have time to cook a meal so they ate cold biscuits, built a canvas shelter, and that the shelter was needed because of a rainstorm that night. Further, the text went on to state that the family returned to the ship in order to gather more supplies. Six of the 11 questions on the second part of the story related specifically to information that was not part of the film.

The comprehension questions on the second part of the story were analyzed as two subtests. Subtest 1 included test questions whose answer was both in the film and in the text. Test questions in subtest 2 contained information that was not in the film; it was only in the text. Table 5 presents the results of <u>a priori</u>, planned comparisons used to analyze subtests 1 and 2.

-Insert Table 5 here-

Results for the first subtest, where the questions related to information present in both the film and text, indicated that the movie-text group performed significantly better than the text only group (contrast 1) while the movie only group performed significantly better than the text only group (contrast 2). A post hoc, Scheffe test indicated that the movie-text group performed significantly better than the text only group. The results suggest that information presented in the film is more readily comprehended than is information presented only in the text. The most important finding, however, is that the combination of film context and text resulted in better comprehension than either film or text alone. These results could be due to the advantages of redundancy between the movie and the text.

Evidence suggesting that the synergy hypothesis is also applicable stems from analyses of the second subset of questions--those testing comprehension of information not shown in the film segment. Results show that the movie-text group performed significantly better than the text only group. As expected, the text only group performed significantly better than did the movie only group, since questions referred to information that was not present in the video. In fact, the mean score for the movie only group ($\underline{X}$=0.45), compared to the text only group ($\underline{X}$=3.00) indicates that students who only saw the film were, in effect, unable to answer the questions. Nevertheless, when the video was combined with the text, students were better able to answer this subset of questions than were those in the text only group.

The latter results suggest a synergistic relationship between prior video context and text. Since the information tested was not presented in the film segment, it is not unexpected that students in the video only group were unable to successfully answer the test questions. By the same token, these findings show that redundancy effects cannot explain superiority of movie-text over text alone. The film did not provide answers to the comprehension questions, yet it helped students understand and remember the text information that was necessary in order to get these questions correct.

The third set of data involve students' comprehension of vocabulary items. As shown in Table 4, provision of a video context prior to reading the selection facilitated students' comprehension of vocabulary items. The movie-text group was better able to generate meanings for the target vocabulary items than were students who only encountered the items in text. This result is not consistent across both the meaning generation and matching tasks. Nevertheless, meaning generation is a more difficult and higher-level task than is matching of words to meanings that have been provided. Meaning generation is also a more ecologically valid measure, since students who encounter new concepts must usually generate their own meanings rather than decide which of several alternatives is correct. Thus, even though prior exposure to video context resulted in significantly better performance only on the meaning generation measure, the result seems important.

In the final task in this experiment, the children were asked to provide a meaningful context for sets of seemingly unrelated sentences (e.g., They saw the shore. He picked up the saw). Sentences such as these were used in Experiment 1 with college students, and the results of Experiment 1 indicated that the video context facilitated students' abilities to make theme-related, sentence-connecting inferences. As indicated in Table 4, similar results were found in the present experiment.

Students in the video plus text group were better able to make meaningful connections among sentences than were those in the movie only group and the text only group.

Discussion. The results of Experiment 3 indicate that viewing a video context prior to reading a related text facilitates performance. Both incidental vocabulary learning and passage comprehension was enhanced by the provision of background knowledge in the form of a video context. This result has direct implications to reading instruction. Durkin (1984) has noted that teachers rarely follow basal reader manuals' suggestions that background knowledge be provided before a reading assignment is given. Durkin (1984) also suggests that one reason teachers do not follow teacher manuals' suggestions is because of the time, both in terms of preparation and in terms of the quantity of instructional time taken by activities such as presentating words in context and provision of background knowledge. According to the results of this experiment, use of a video context on which instruction can be based is one way to provide such context with little time expenditure for preparation on the teacher's part.

The most important result of Experiment 3 involves the synergistic relationship between video and text. For example, students who saw only the video segment were unable to provide answers to a number of comprehension questions. The answers to these questions were provided in the text. Nevertheless, students who read the text plus saw the video performed much better than did those who read the text without seeing the video. The text therefore added information that was not available in the video, but the latter helped students understand and remember the text. Similar results were found for the incidental vocabulary learning, where students tried to infer the meaning of words embedded in the text.

Since it took approximately 12 minutes to show the video segment, one could argue that the use of video segments take valuable time away from instruction. We argue that this is not necessarily the case. In particular, the same video segments could be used for a variety of activities such as writing assignments, mathematical word problems, science lessons and so forth. Since the video segments we used were highly interesting to the students, they provide a break from normal routines yet can also be extremely valuable for subsequent instruction. Ultimately, we believe that the effective use of video segments can increase the efficiency of learning rather than detract by taking time away from academic tasks.

The students who participated in Experiment 3 were all below grade level in reading ability, but that does not mean that average or above average students cannot benefit from video segments. As shown in Experiments 1 and 2, for example, even college students process information more effectively when supplied with appropriate contextual information. Video contexts should have their greatest benefits when students have difficulty supplying such information on their own.

## Overall Discussion

The results of all three experiments provide evidence that Haven-like environments can produce increases in comprehension and learning. Data from Experiment 1 illustrate that college students can be helped to (a) make inferences necessary to fill in the gaps in messages, (b) understand the meaning of unfamiliar words, and (c) interrelate various topics or lessons that otherwise seem unrelated. The results of Experiment 2 show that the creation of rich learning environments can help college students elaborate on information and increase their perceptions of its interest and relevance. Experiment 3 provides evidence that effective learning environments can facilitate sixth graders' abilities to understand new concepts and to answer questions about what they read.

In each of the experiments we were able to facilitate comprehension and learning by using video segments to provide a rich context for learning, and by creating spoken or written materials that helped students elaborate on the contexts. In general, we tried to create learning environments that included some of the advantages available to humans during the initial years of their lives. Nevertheless, none of our experiments used environments that we consider to be ideal Havens. The concept of a Haven is more complex than the learning environments used in our studies. Nevertheless, even these simple environments resulted in increases in comprehension and learning. Ideally, Havens involve an environment that is (a) highly motivating, (b) provides mediated guidance within a context-rich microworld, and (c) keeps detailed records of student interactions with the computerized microworld. These aspects of Havens are discussed more fully below.

First, it is important to note that video segments are only one of many possible ways to create rich contexts within which mediation can take place. As mentioned in the introduction to this paper, existing software programs (e.g., How the West was Won) and existing programming environments such as Logo can be used to create Havens for learning. Nevertheless, many current uses of software programs and of Logo seem to involve only minimum mediation and hence seem to miss many opportunities for learning. Similarly, if students are shown only video segments from films such as Swiss Family Robinson or Raiders of the Lost Ark, they fail to notice the many opportunities for new learning. They need guidance to focus their attention on important issues. The Havens concept emphasizes that more attention must be given to the nature of the instructional context within which computer-based activities take place (e.g., see Pogrow, 1985).

The Havens concept also has implications for the design of studies to assess the effectiveness of technology-based learning. In studies of Logo, for example, students are often trained in programming and then given transfer measures designed to assess very general skills such as planning (e.g., Pea and Kurland, 1983). It is difficult to know whether the new contexts of application provide adequate tests of these general strategies. When Logo is viewed as a potential Haven, the emphasis is on its ability to provide a context within which important concepts can be introduced and made meaningful. A natural research design is therefore to assess students' abilities to learn about particular concepts (e.g., angles, the use of protractors) as a function of whether these are introduced in a Logo context or in typical instructional situations involving lecture, discussion and texts.

At present, we have several prototype Havens that are currently under development. These are based on the present findings plus a number of design principles derived from the motivation and instuctional effectiveness literature (e.g., Lepper, 1985). To begin, the Havens are designed to maximize student attention as they engage in learning. One way in which this can be done is through the use of fantasy. In the prototype Havens we do this by building a fantasy environment around popular films such as Raiders of the Lost Ark, Swiss Family Robinson, Star Wars, and King Kong. In these Havens, learners are placed in more active roles than they were in the present experiments. Their goal is to assist characters in the film to solve problems as they go through an adventure together. For example, in using the movie Raiders of the Lost Ark, the learner has to assist Indiana Jones in solving numerous math and science problems that are encountered in his quest to retrieve a golden idol. In contrast, in the movie Swiss Family Robinson, the learner must help the family solve the problems associated with survival following a shipwreck. In both cases the films provide a motivating environment in which problems can be solved in a context-rich microworld.

Motivation can be further enhanced in a Haven by placing the adventure within a game context, where the student scores points for successfully solving problems and loses points or even has to start the adventure from the beginning if he or she fails to solve the problems successfully. In this respect, Havens resemble some of the common computer-based adventure games. One important difference, however, is that in a Haven, problem solving is more academically oriented than in most other adventure-type games.

An additional characteristic found in all Havens is "mediated guidance." Mediation is provided in terms of guidance about what to notice and feedback about one's performance. For example, in his quest for the golden idol, one of the problems that Indiana Jones is faced with is the removal of the idol from a weight-sensitive pedestal that will set in motion a catastrophic set of events if a change in weight is detected. Thus, Indiana must remove the idol while simultaneously replacing it with a item of equal weight. At this point, the problem presented to the student working through the Haven is to determine if a bag of sand that Indiana is going to put in place of the golden idol weighs the same as the idol. Without this type of prompting, many students fail to ask themselves whether it is reasonable to assume that a solid gold idol would weigh the same as a small bag of sand.

In order to solve the preceding problem, the student must use knowledge and principles from math and science. The student must determine the mass of the idol by estimating the idol's volume and must then multiply this by the specific gravity of gold. Next, the student must calculate the mass of the sand in the leather bag by the same procedure. If the student does the calculations correctly, he or she will know that the weight sensitive pedestal will detect a change in weight since the mass of the idol is far greater than the mass of the sand. In this case the student receives points for correctly solving the problem and is able to continue through the adventure.

If students fail to solve the problem they lose points and then receive mediation in order to solve the problem correctly. Using text, audio, and graphic feedback, the students are questioned and prompted until they are able to solve the problem. At this point, if the students' scores have not fallen to zero they are allowed to continue through the adventure. If no points remain they must return to the beginning of the adventure and start again. This time they and Indiana will encounter a new set of adventures and problems.

We are especially interested in helping students develop the ability to identify new problems on their own, and to create their own problem solving adventures that others can attempt to solve. This emphasis on problem identification and problem generation seems to be an especially important aspect of problem solving that is often absent in instructional settings (e.g., Bransford and Stein, 1984). The use of commercial video segments is especially good for problem identification because these contain many instances where events do not fit reality either because of mistakes or because of "artistic intent". Part of our work is therefore aimed at creating software that permits students to design their own adventures. In addition, we are attempting to create data bases that students can access in order to find information (e.g., about spiders, density, etc.) that helps them design adventures of their own.

The final characteristic of all Havens is their ability to keep detailed records of students' interactions as they go through the Haven. These records are integral to the successful Haven since a single Haven may have multiple adventures of varying levels of difficulty. By keeping track of students' responses, a tailored adventure can be constructed for the learner, making sure that the appropriate mix of problem difficulty is presented to the student in order to maximize motivation and learning. A second reason for storing student responses and interactions is for diagnostic purposes. By reviewing a students' record of responses, one is often able to diagnose specific problems a student is exhibiting in the problem solving process, thus enhancing the quality of remediation. If these response data are not captured there is little hope of assessing a student's specific problems.

The Havens currently under development are heavily reliant on videodisc and computer technology. At present, the student interacts with the Haven through an IBM PC that is interfaced with a Pioneer 1000 videodisc player. The PC controls the videodisc through a proprietary authoring system developed by IBM, and the PC and disc player use a common video monitor. Using the authoring system, the setting for an adventure is created for the student using text, graphics, and audio. The student is then taken through the adventure by viewing selected segments of the film on which the adventure is based. As described above, the student must solve problems successfully in order to continue through the adventure. By combining videodisc technology with the text and graphics capabilities of the authoring system, we are able to create extremely flexible and powerful Havens around adventures portrayed in some of children's favorite movies. The Havens can be used by groups of students or by individuals working alone.

In sum, the data from all three experiments suggest that Haven-like learning environments are successful in enhancing comprehension and learning. We refer to these environments as "Haven-like" because they involve relatively simple uses of technology and of teacher support. They therefore fall short of the ideal. Nevertheless, it seems important to attempt to understand and document how even simple uses of technology can improve student learning--especially given the skepticism among many educators concerning claims about the "panacea" offered by computers in the schools. By showing how even simple uses of technology can facilitate comprehension, learning and problem solving, the stage is set for exploring how more sophisticated uses of technology can enhance learning to even greater degrees.

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Table 1

Descriptive Statistics and *t* Values for Groups and Measures

| | | Measure | | | |
|---|---|---|---|---|---|
| Group | *n* | Difficult Sentences | Nonsense Words | Inferences | Memory |
| Film | 14 | $\bar{X}$ = 39.79 | 4.79 | 4.93 | 12.54 |
| | | *SD* = 10.35 | 0.58 | 0.27 | 3.23 |
| Control | 12 | 26.83 | 2.00 | 0.42 | 10.33 |
| | | 6.31 | 1.58 | 0.52 | 2.18 |
| | *t* value[a] | 3.77 | 6.05 | 28.65 | 1.78 |

a $p < .001$ for first 3 measures, $p < .05$ final measure, one tailed test

Table 2

Descriptive Statistics for Student Ratings of Information and Sentences

| Group | | | Measures: Density Passage Ratings | Measures: Sentences Ratings |
| --- | --- | --- | --- | --- |
| Exp. | Pretest | $\bar{X}$ = | 3.25 | 4.07 |
| | | $s$ = | 0.94 | 0.50 |
| | Posttest | | 4.13 | 4.68 |
| | | | 0.86 | 0.12 |
| Control | Pretest | | 2.75 | 3.93 |
| | | | 1.19 | 0.47 |
| | Posttest | | 3.00 | 3.92 |
| | | | 2.50 | 0.58 |

Table 4

Summary Table: Experiment 3

| | $\bar{X}$ | SD | df | t | p* |
|---|---|---|---|---|---|
| VOCABULARY (set 1) (Generate Meaning) | | | | | |
| Contrast 1 | | | | | |
| movie | 5.75 | 1.72 | | | |
| | | | 26 | -1.83 | 0.04** |
| movie-text | 7.28 | 1.91 | | | |
| Contrast 2 | | | | | |
| movie-text | 7.28 | 1.91 | | | |
| | | | 26 | 0.69 | 0.25 |
| text | 6.70 | 1.84 | | | |
| VOCABULARY (set 1) (Matching) | | | | | |
| Contrast 1 | | | | | |
| movie | 8.80 | 1.40 | | | |
| | | | 26 | -2.36 | 0.02** |
| movie-text | 9.78 | 0.67 | | | |
| Contrast 2 | | | | | |
| movie-text | 9.78 | 0.67 | | | |
| | | | 26 | -0.54 | 0.30 |
| text | 10.00 | 0.00 | | | |

(table continues)

| | $\bar{X}$ | SD | df | t | p* |
|---|---|---|---|---|---|
| COMPREHENSION | | | | | |
| (Part 1, Total) | | | | | |
| ------------- | | | | | |
| Contrast 1 | | | | | |
| movie | 6.10 | 1.47 | | | |
| | | | 26 | -3.14 | 0.00** |
| movie-text | 8.83 | 2.21 | | | |
| Contrast 2 | | | | | |
| movie-text | 8.83 | 2.21 | | | |
| | | | 26 | 2.17 | 0.02** |
| text | 6.95 | 1.96 | | | |
| COMPREHENSION | | | | | |
| (Part 2, Total) | | | | | |
| ------------- | | | | | |
| Contrast 1 | | | | | |
| movie | 2.60 | 0. | | | |
| | | | 26 | -5.13 | 0.00** |
| movie-text | 7.28 | 2.60 | | | |
| Contrast 2 | | | | | |
| movie-text | 7.28 | 2.60 | | | |
| | | | 26 | 3.26 | 0.00** |
| text | 4.30 | 2.11 | | | |

| | $\bar{X}$ | SD | df | t | p* |
|---|---|---|---|---|---|
| VOCABULARY (set 2) | | | | | |
| (Generate Meaning) | | | | | |
| ------------- | | | | | |
| Contrast 1 | | | | | |
| movie | 4.60 | 1.58 | | | |
| | | | 26 | -2.87 | 0.00** |
| movie-text | 6.78 | 1.28 | | | |
| Contrast 2 | | | | | |
| movie-text | 6.78 | 1.28 | | | |
| | | | 26 | 3.20 | 0.00** |
| text | 4.35 | 1.99 | | | |
| VOCABULARY (set 2) | | | | | |
| (Matching) | | | | | |
| ------------- | | | | | |
| Contrast 1 | | | | | |
| movie | 7.80 | 2.25 | | | |
| | | | 26 | -0.96 | 0.17 |
| movie-text | 8.67 | 2.00 | | | |
| Contrast 2 | | | | | |
| movie-text | 8.67 | 2.00 | | | |
| | | | 26 | 0.74 | 0.24 |
| text | 8.00 | 1.56 | | | |
| CONTEXT | | | | | |
| ------------- | | | | | |
| Contrast 1 | | | | | |
| movie | 1.40 | 0.84 | | | |
| | | | 26 | -3.16 | 0.00** |
| movie-text | 2.50 | 0.50 | | | |

| | $\bar{X}$ | SD | df | t | p* |
|---|---|---|---|---|---|
| Contrast 2 | | | | | |
| movie-text | 2.50 | 0.50 | | | |
| | | | 26 | 2.88 | 0.01** |
| text | 1.50 | 0.84 | | | |

* One-tailed

** $p < 0.05$

Table 5

Summary Table for Comprhension Subtests

| | $\bar{X}$ | SD | df | t | p* |
|---|---|---|---|---|---|
| COMPREHENSION (Part 2, Sub 1) | | | | | |
| Contrast 1 | | | | | |
| movie-text | 3.00 | 1.25 | 26 | 3.84 | 0.00** |
| text | 1.30 | 0.98 | | | |
| Contrast 2 | | | | | |
| movie | 2.15 | 0.58 | 26 | 1.97 | 0.03** |
| text | 1.30 | 0.98 | | | |
| COMPREHENSION (Part 2, Sub 2) | | | | | |
| Contrast 1 | | | | | |
| movie-text | 4.28 | 1.95 | 26 | 1.87 | 0.04** |
| text | 3.00 | 1.58 | | | |
| Contrast 2 | | | | | |
| movie | 0.45 | 0.68 | 26 | -3.84 | 0.00** |
| text | 3.00 | 1.58 | | | |

* One-tailed

** $p < 0.05$