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ABSTRACT

A study was carried out at Pennsylvania State University to examine the effects of both textual and computer animated orienting activities--i.e., mediators through which new information is presented to the learner--and practice on the application and problem solving skills of elementary school students. It was hypothesized that students provided with orienting materials containing textual and animated information would acquire both skills more effectively than students provided either activity alone or neither activity. It was further hypothesized that practice would be of greatest value where orienting support was minimal. Subjects consisted of 111 fourth, fifth, and sixth grade students from a rural public elementary school who were randomly assigned to either a text, animated, or text plus animated orienting activity group, or to a control group having no orienting activity. Groups were divided into practice and no practice subgroups. Upon completion of the computer-assisted instruction lesson, students were administered a posttest measuring both application and problem solving skills. Results indicated that the nature of the orienting activity did not affect the learning of either application or problem solving skills; however, practice was found to hamper performance for both skills, and no interactions were detected. (MES)

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## Abstract

In this study, the effects of textual versus animated orienting activities and practice on the learning of elementary science material was studied. Elementary school students were randomly assigned to either a Text, Animated, Text plus Animated orienting activity group or a control group having no activity, and to either a Practice or No Practice group. Upon completion of the lesson, students were administered a posttest measuring both application (rule-using) and problem solving (higher order rule-using). Results indicated that the nature of the orienting activity did not affect the learning of either application or problem solving skills. However, a negative effect was found for practice.

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In this study, the effects of textual versus animated orienting activities and practice on the learning of elementary science material were studied. Elementary school students were randomly assigned to either a Text, Animated, Text plus Animated orienting activity group or a control group having no activity, and to either a Practice or No Practice group. Upon completion of the lesson, students were administered a posttest measuring both application and problem solving skills. Results indicated that the nature of the orienting activity did not affect the learning of either application or problem solving. However, a negative effect was found for pr. tice.

Introduction

The science of instructional design has become increasingly interesting and complex. Recent interest in instructional design has focused on the potential of computer technology to deliver effective and efficient instruction. Much research has shown that carefully designed instruction can be delivered effectively via computer (see, for example, Edwards, Norton, Taylor, Weiss & Dusseldorp, 1975; and Bangert-Drowns, Kulik, & Kulik; 1985).

Certain features of computer technology are well-suited to the needs of instructional designers. For example, instruction can be delivered repeatedly across learners without random variation. Other features, such as the ability to branch to appropriate lesson segments based on individual learner needs and to provide appropriate and immediate feedback can be easily incorporated into computerized instruction. Lesson designers can also incorporate a wide range of teaching strategies and activities into computer-based instruction (CBI).

One goal of CBI designers is to utilize capabilities presumed to be unique to the computer. Though controversy exists as to the unique effectiveness of the computer as an instructional tool (see, Petkovich & Tennyson (1984 ) vs. Clark (1983); Clark, 1985), certain capabilities offer interesting instructional potential. Animation is one such capability which can be more easily integrated into computerized instruction than other instructional systems. For the purposes of this paper, animation is a series of rapidly changing computer screen displays that presents the illusion of movement (Caraballo, 1985). Computerized instruction has typically used animation as an extrinsic motivator involving such things as cartoon figures acting as feedback to student's responses. However, animation can also be used to support or enhance instruction directly and indirectly. An example of instructionally supportive animation is the animated block accelerating down an inclined plane to teach a concep' in a physics class. (See Alesandrini, 1984, for a discussion of the use of visuals in instruction.)

Many perspectives on the design of effective instruction exist. Recent interest has shifted to the influence of cognitive processes during instruction (Clark, 1984; Gagne' & Dick, 1985; Hannafin & Rieber, 1986). CBI designers attempt to strengthen learning by encouraging individually relevant cognitive processes through various lesson activities or events (Gagne', Wager, & Rojas, 1981). Recent attempts to improve learning through the use of orienting activities have also been reported. An orienting activity is a mediator through which new information is presented to the learner (Hannafin & Hughes, 1986). Orienting activities comprise advance organizers, pre-instructional objectives, pre-questions, and other similar techniques (see, for example, Allen, 1970; Alvermann, 1981; Ausubel, 1960; Kaplan & Simmons, 1974; Mayer, 1979, 1984; Walsh & Jenkins, 1973). Interestingly, the effectiveness of orienting activities during CBI has been inconsistent (Hannafin, Phillips, Rieber, & Garhart, 1986).

Recent research has demonstrated the power of practice to override effects normally expected from orienting activities (see, for example, Hannafin, 1986; Hannafin, Phillips, & Tripp, 1986). Researchers have speculated that practice often subsumes effects expected from orienting activities alone. This is consistent with the guidelines provided by Mayer (1979), who suggested that advance organizers are often unnecessary in the presence of well-designed instruction. In certain cases, practice activities may also orient learners to subsequent instruction (Phillips, Hannafin, & Tripp, 1986).

The purpose of this study was to examine the effects of different orienting activities and practice on application and problem solving skills of elementary school students. It was hypothesized that students provided orienting activities containing textual and animated information would acquire both skills more effectively than either activity alone or neither activity. It was further hypothesized that practice would be of greatest value where the orienting support was minimal.

## Methods

### Subjects

The subjects consisted of 111 fourth, fifth, and sixth graders from a rural public elementary school. These subjects represented approximately 80% of the student population of these grades. Participation was voluntary and selection based on parent consent. The subjects represented a typical cross-section of students typically found in an elementary school. The subjects consisted of 56 girls and 55 boys. The proportion of subjects across grade levels were 24 fourth grade, 41 fifth grade, and 46 sixth grade.

### CBI Lesson Content

The CBI lesson described and explained Isaac Newton's Laws of Motion. The lesson material was divided into four parts: 1) introductory material; 2) motion resulting from equal forces in opposite directions in one dimensional space; 3) motion resulting from unequal forces in opposite directions in one dimensional space; and 4) motion resulting from equal and unequal forces in two dimensional space.

The first lesson part introduced the learner to Isaac Newton's formal discovery of certain physical laws. This part also initiated the sequence of learning activities used for the rest of the lesson. Most of the information presented in the first part was factual in nature. The second part introduced the concept that equal but opposite forces are needed to cause objects to stop. This section dealt only with one-dimensional space. The third part expanded this notion to include the effects of unequal forces acting upon a stationary object. The final direction and speed of an object is a combination of all of the forces from both directions. The third part also presented these concepts in one-dimensional space. Finally, the fourth part added the notion of two-dimensional space to the above concepts. Again, the final direction and speed of the object results systematically from the sequence of forces which acted upon it.

Each of the four lesson parts included the same two instructional segments in the same sequence: appropriate orienting activity and instructional frames. All instruction was presented at an introductory level with the technical descriptions of the forces of gravity and friction removed. Approximately 30 minutes was required to complete the lesson.

### Lesson Versions

Each lesson included one of four orienting activities. Each orienting activity was controlled and paced externally and was presented immediately prior to each lesson part. Each orienting activity was presented for approximately one minute.

*Text.* In this orienting activity, a text-only computer screen prompted the learner to read a one sentence summary of the basic physical science concept to be discussed in the upcoming lesson part. An example of a text orienting activity is: "Read the following information carefully. It will help you in the next section. In order for a moving ball to completely stop, all forces must be EQUAL in all directions."

*Animation.* In this orienting activity, the learner was prompted to watch a short animation sequence. The animation sequence illustrated graphically a science concept without the use of textual information. An example of this activity is: "Watch the little ball below carefully. It will help you in the next section." A small ball was then kicked once to the right (a small arrow on the screen represented a kick) while ball movement was animated in a left to right fashion. When kicked once to the left, the ball stopped.

*Text plus Animation.* This orienting activity was the combination of the above two strategies. The text and the animation orienting activity described above were shown together on the same frame while the learner was prompted to read and watch the information carefully.

*No Activity.* In this activity, the learner was given no information about the upcoming lesson. However, the lesson paused for roughly the same time required for the orienting activities while the following prompt was given: "The computer will be busy for about a minute. Please think about what you've read so far while you wait."

Each of the orienting activities was used in conjunction with one of the two practice variables: Practice and No Practice. The practice was provided immediately after each of the four lesson parts.

*Practice.* Learners were given a variety of activities to rehearse the lesson concepts. For example, one practice activity displayed a series of left and right arrows representing a sequence of kicks. The learner was then asked to choose which of four given outcomes would best describe the final motion of the ball. After responding, appropriate feedback in the form of knowledge of correct results was provided while the computer animation of the kick sequence was presented. During another practice activity, the ball was animated according to a predesigned pattern. The learner was then asked to choose which of four given kick sequences best described the motion of the ball. After responding, the learner was given appropriate knowledge of correct results. Similar practice activities were used throughout the lesson.

*No Practice.* In this version, students received no practice after the presentation of the lesson information. After the appropriate lesson presentation, the learner was routed directly to the orienting activity of the next lesson part.

### Lesson Posttest

The 24 item posttest consisted of two types of questions: application and problem solving (Gagne', 1977). A total of 12 application questions and 12 problem solving questions were included in the posttest.

## Design and Data Analysis

A 4 X 2 factorial design was used. Four levels of orienting activities (Text, Animation, Text plus Animation, None) were crossed with two levels of practice (Practice, No Practice). In addition to the independent variables, an overall achievement grade equivalent score of a standardized achievement test, was used as a covariate. This score was used in order to minimize the effects of imbalance of students from different grade levels in the various treatment combinations. MANCOVA procedures were used to analyze performance data.

## Procedures

Subjects were randomly assigned to one of the lesson versions and the lesson was presented accordingly. Assignment was proportionally stratified to ensure balance of subjects from achievement levels in each lesson version. All instruction and testing was administered by computer in a lab containing microcomputers. Upon completion of the lesson, students were prompted to inform the proctor. The posttest was given to the students immediately upon completion of the lesson.

# *Results*

Table 1 contains adjusted means for each treatment combination. No overall MANCOVA significant differences were found for orienting activities $F(6,204) = 1.13$, $p > .05$. Mean scores were comparable irrespective of the orienting activity provided. A marginally significant effect was found for practice $F(2,101) = 3.67$, $p < .05$. However, the direction of this effect was not predicted. Practice actually hampered performance for both application and problem solving skills. No interactions were detected.

# *Discussion*

The purpose of this study was to examine the effects of text-based and computer animated orienting strategies and practice on learning application and problem solving skills. The results suggest that orienting activities, whether text-based or animated, do not exert particularly powerful influences on learning.

The lack of differential effects attributable to orienting activities during computer-based instruction was consistent with several recent studies involving computer-based learning (Hannafin, 1986; Hannafin, Phillips, Rieber & Garhart, 1986; Hannafin, Phillips, & Tripp, in press). However, the activities used in the present study were believed to be consistent with the capabilities of the computer and were believed to provide powerful orienting mechanisms. The textual orientation provided a verbal representation of the science concept while the animation provided a mental image of each particular science concept.

Cognitive psychology researchers have posited mental imagery and verbal representations as primary mental structures. Many researchers have noted the power of pictures over abstract words in stimulating higher levels of retention (see for example, Bower, 1972; Paivio, 1979). This research suggests that young learners are often better able to receive information in visual versus textual ways. When information is presented in highly verbal ways, young learners often create a mental image corresponding to the presented text. The implication is when instruction contains meaningful visual images to support lesson information, such as in the text plus animation treatment, learners *should* be better able to both store and retrieve the information to and from long term memory.

There are several explanations which may help to clarify why an orienting activity effect was not found. First, orienting activities, such as advance organizers, are probably most useful when the subject matter lacks organization (Mayer, 1979). The instruction used in this study was carefully prepared and presented and may have subsumed potential learning gains derived from orienting activities. Due to the apparent difficulty of the lesson content, it is also possible that students never fully elaborated the material during encoding and were therefore less able to retrieve lesson information. Lastly, another possible explanation comes from Carlson, Kincaid, Lance & Hodgson (1976) who noted that students tend to revert to their own individual strategies regardless of strategy prompting during instruction. Hence, many students might simply disregard or ignore the potentially useful information or orienting strategies in favor of their own individual strategies.

The absence of the predicted interaction between orienting activity and practice was somewhat surprising. It was hypothesized that practice would decrease in power as the potential meaningfulness of material was increased. This should also be true when children are provided with elaboration or preparatory mechanisms to better encode information. It was predicted that the text plus animation activity would lessen the effect of practice since additional elaboration cues were available at the time of encoding. The absence of the interaction is probably due to the ineffectiveness of the orienting activities already discussed; orienting activities simply did not make a difference in a fully supported CBI lesson.

Practice actually exerted a negative influence on learning in this study. This result is inconsistent with other findings and should be interpreted cautiously. It is evident from an analysis of the low posttest means that the lesson material was very difficult for students to acquire. Providing additional instruction, where heavy cognitive demands were already imposed upon the learner, may have been more detrimental than helpful to learning. The additional demands of practice may have created a type of cognitive overload. This phenomena is consistent with research from other areas of instructional design such as the use of visualization. Dwyer (1978), for example, found that although the use of pictures generally facilitated learning, this was not generally true when the material to be learned was too complex. Lesson designers should be cautious in the use of additional activities when lesson material is very complex and demanding.

Several directions for further research are indicated. Although the use of animation to enhance learning appears consistent with current theories of learning, recent studies have failed support this contention (see also, for example, King, 1975; Moore, Nawrocki & Simutis, 1979; A. Caraballo, 1985; and J. Caraballo, 1985). Continued research is needed to better define where the power of animation is useful and appropriate. Although the computer can deliver instruction in a variety of modes based on a variety of conditions, such conditions must be better defined. Additional research is needed to define optimal contexts for orienting activities and practice.

This study has raised several questions concerning how students process information, as well as how computer technology can contribute to this learning process. Based on this study, it appears that orienting activities are relatively insignificant in affecting learning when part of a well designed lesson. The negative effect of practice, though perhaps a statistical anomaly, warrants closer study. Future researchers should clarify and define superior instructional design models given the evolving capabilities of technology.

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Table 1:

Adjusted Means for Application and Problem Solving Questions

| | | Orienting Activity | | | |
|---|---|---|---|---|---|
| Embedded Activity | | Text | Animated | Text + Animated | None |
| | | Application | | | |
| Practice | Mean | 4.84 | 5.45 | 4.40 | 4.86 |
| | n | 14 | 14 | 14 | 13 |
| No Practice | Mean | 6.13 | 4.86 | 5.08 | 4.24 |
| | n | 14 | 14 | 14 | 14 |
| | | Problem Solving | | | |
| Practice | Mean | 5.39 | 4.86 | 4.29 | 5.14 |
| | n | 14 | 14 | 14 | 13 |
| No Practice | Mean | 5.92 | 5.22 | 6.22 | 6.06 |
| | n | 14 | 14 | 14 | 14 |