Two Computer-Graphics Variations (Animated vs Still) and their Impact on the Knowledge and Performance of Cognitive-Behavioral Skills: Fire-Safety Training

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(ABSTRACT)

Fifty-six fourth-grade children served as participants in this study. Three training procedures (behavioral, animated-graphics, and still-graphics) were assessed for relative effectiveness in the acquisition of fire emergency skills and attainment of knowledge. Each of the training groups was compared to a no-treatment control group. Performance on dependent measures was assessed prior to and immediately following training. Hypotheses predicted that the behavioral and animated graphics conditions would produce the greatest level of skill and knowledge acquisition. Results demonstrated a significantly higher level of fire emergency skill acquisition and knowledge attainment for both the behavioral and animated graphics groups relative to the still graphics and no-training groups. The value of using animated versus static images in computerized instruction for fire-safety skills training was demonstrated.

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Chapter 1—Introduction

Background

Modern pedagogy offers a variety of instructional techniques which are designed to help students learn and/or develop skills. One such method is computer assisted instruction (CAI). Yet CAI, or any other single style or strategy (e.g., role playing, group investigation, nondirective teaching), cannot be didactically presented as a rigid and static prescription for learning (Joyce & Weil, 1986). Each method clearly requires persistent sensitivity and continuous inquiry by both researchers and practitioners.

Over the last decade, CAI researchers have gathered and analyzed empirical data while directing their efforts toward the development of a theoretical and practical framework for the use of microcomputers in instruction and learning. Unanswered questions still remain, however, despite this vigorous activity and resultant progress. These knowledge gaps partially stem from the limited manner in which microcomputers have been utilized in learning environments. That is, the independent use of the microcomputer as an aid to instruction has been restricted to the development of skills which are primarily cognitive in nature (e.g., math, science, reading). Since one's overall learning requires the development of skills which lie outside the purely cognitive domain, the investigation of ways in which CAI might be used to facilitate other types of learning is warranted.

Microcomputers are generally perceived as being able to: (1) replace or supplement traditional instruction; (2) increase student-teacher ratios while simultaneously increasing learning; (3) increase retention; (4) decrease learning time; (4) be equally effective in achievement across a wide range of content areas and student populations; and (5) have unique effectiveness in teaching attitudes and problem-solving skills (Roblyer, 1985). The increasing popularity of CAI has been attributed to its cost effectiveness, with numerous citings reported where large groups of learners have received quality instruction at minimal cost (Schramm, 1977). Research findings also show that CAI not only provides instructors with a means of performing tasks which, ordinarily, seem too difficult to accomplish (Petkovich & Tennyson, 1984), but also increases instructional efficiency in the form of time-savings (Jamison, Suppes, & Welles 1974).

Purpose of the Study

It was the purpose of this research project to investigate two CAI variations ("animated" graphics and "still" graphics) for their effectiveness in training children to cope with stress induced by fire-related emergencies. Moreover, both of these CAI components were evaluated first as a **supplement**, and then secondly, as a **substitute** to conventional (i.e., behavioral) teaching methods used previously in this type of training.

Two principal reasons served as the basis for selecting fire-safety skills as the domain in which to conduct the study. First, there was little or no extant research on the use of CAI in the development of cognitive-behavioral skills; especially, those coping skills pertaining to fire emergencies. Secondly, in view of the potential opportunities to reduce childhood trauma and injury related to fires, continued research and study in this area would offer practical benefits.

Children regularly encounter stress-inducing situations (e.g., schooling, personal injury, puberty). Perhaps not as frequent, yet potentially more severe than others, is stress caused by fire. In fact, children have been cited as major contributors to, or victims of fires (Burger King, 1979; NFPA, 1975a). Consequently, they are often designated as prime targets for the teaching of preventive measures for fire-related injury. A number of organizations and independent researchers have initiated projects to reduce child injuries and fatalities related to fire (American Telephone and Telegraph, 1975; NFPA, 1975b; Risley & Cuvo, 1980). Until recently, however, these undertakings were limited to identifying specific emergencies (e.g., school fire drills) or using the telephone to call for assistance (Jones & Kazdin, 1980).

The design used in the study was a partial replication of earlier fire-safety research conducted by Jones and his colleagues (Jones & Kazdin, 1981; Jones, Ollendick, McLaughlin, & Williams, 1989). Three training procedures (Behavioral, Animated-graphics, and Still-graphics) were assessed for relative effectiveness in the acquisition of fire emergency skills and attainment of knowledge. Each of the training groups was compared to a no-treatment control group. Performance on dependent measures was assessed prior to and immediately following training. Hypotheses predicted that the Behavioral and Animated-graphics conditions would produce the greatest level of skill and knowledge acquisition.

Whether CAI via the microcomputer represents an appropriate methodology to use in the acquisition and maintenance of cognitive-behavioral skills in general, and fire-safety skills in particular, remains an empirical question. Attempting to understand the uniqueness of this teaching-learning interaction and the individuality of the participants involved provide a foundation for this investigation.

Chapter 2—Literature Review

Overview

The acquisition and performance of fire safety skills such as rolling out of bed, crawling to the door, opening the door, etc., requires both mental and motoric activity. Ideally, any training in these skills should employ instructional methods which target both cognitive and behavioral dimensions of learning.

CAI is generally perceived as a cognitively-based instructional technique. Fire-safety skills, however, are not strictly cognitive; rather, they are "dual" (cognitive and behavioral) in nature -- with a higher percentage falling in the behavioral domain. Mastery of these skills is more heavily dependent upon actual performance, rather than mental reenactment of the skill. It is appropriate, therefore, to test whether CAI is an effective facilitator of learning in this novel setting.

Since its inception in the early seventies, CAI has been primarily tailored for those disciplines which do <u>not</u> emphasize motor learning (e.g., reading, writing, mathematics, science). This suggests that CAI may be inferior in its instructional value when applied to motor-type learning. The challenge to prove otherwise, however, serves as the principal motivation of this investigation.

First, an aggregate of specific research findings in the area of fire-safety training is presented. Research literature on motor learning, symbolic modeling, visual learning, elaboration, and feedback provide a theoretical and empirically-based foundation for the study. Finally, relevant CAI research is presented. That is, the review assesses CAI for its past performance, while subtly advocating its use as a fire-safety skills training technique.

Coping Skills (Fire Safety) Training

Coping skills training among children has attracted the interest of a number of behavioral therapists and researchers (Bower, 1964; Garmezy, 1981). Training of this type promotes the development of techniques which can be utilized by children to cope with a variety of stress-inducing, life situations, or "stressors". One major child stressor is fear of personal injury and/or death related to fire emergencies. In fact, fear of fire, or injury caused by fire, is reported as the second, most feared, life-threatening event among children (Ollendick, 1983). Thus, the development of strategies to "master, tolerate, or reduce" (Folkman & Lazarus, 1980) stress related to fire is most appropriate.

Several researchers have systematically developed a set of procedures which effectively promote the mastery of fire-safety skills among children. These skills have been clearly demonstrated as appropriate child-coping strategies to be used in the event of a fire emergency. To date, procedures used to train children in these coping skills have employed a variety of behavioral and cognitive-behavioral instructional techniques (e.g., positive reinforcement, modeling, feedback, role playing, behavioral rehearsal, and elaborative rehearsal).

Initial projects (Jones, 1980; Jones, Kazdin, & Haney, 1981) focused on teaching children how and when to make emergency phone calls. Studies that followed (Jones & Haney, 1984; Jones & Ollendick, 1986; Jones, Van Hasselt, & Sisson, 1984) concentrated on teaching children how to evacuate a fire- emergency situation. In all of these investigations, a behavioral approach was used as the primary instructional method for teaching fire-safety skills. The researchers found that in-vivo modeling (trainers demonstrating and performing the skills), verbal instructions (e.g, "Roll out of bed . . . Get on your hands and knees . . . Now, crawl to the door"), and verbal feedback (e.g., "Good job! . . . That's correct") were effective behavioral training techniques. However, behavior gains significantly declined at nine-month follow-up. This led Jones and his colleagues to explore techniques that would better facilitate maintenance.

A substantial amount of research has been conducted on the use of cognitive self-control strategies in the modification of behavior. These techniques have been found to yield a greater level of maintenance and generalization than many other behavioral techniques (Kazdin, 1980; Meichenbaum, 1977). Thus, in an attempt to improve maintenance, Jones and Haney (1984) tested the effectiveness of a cognitive-behavioral strategy consisting of self-instruction, self-monitoring, self-evaluation, self-verbalization, and self-reinforcement. That is, subjects were first required to "think" about the steps to a procedure and, as an indication of these thought processes, state them out loud (e.g., "Now I'm going to roll out of bed . . ."). Self-evaluation involved the subject's stating such things as "I'm doing great! I just did that step correctly . . . I'm ready for the next one!").

The children who used this strategy were compared to a group of children who used an external, behavioral instructional strategy. The children in the external instructional strategy were simply given behavioral training on fire-safety skills. Additionally, there was a control group employed. Children in the control group received no training.

The results indicated that children trained in the cognitive-behavioral group demonstrated higher levels of maintenance than the children trained in the behavioral groups. These findings suggested that the self-regulatory cognitive components of training in the cognitive-behavioral group did contribute to the maintenance of the skills taught to the children. The researchers felt that the extended maintenance achieved in this group was due partly to the subject's having a more active role in learning the skills. That is, subjects were able to participate more because of the added self-instruction, self-evaluation, and self-reinforcement requirements.

The above research literature indicates that, in addition to overt practice, a number of cognitive teaching strategies (verbal rehearsal, memorization, elaboration) have been utilized in fire-safety-skills training. Expected learner outcomes, on the other hand, are primarily behavioral in nature. Consider, for example, the effect of merely recalling the steps associated with a particular fire-safety skill. In the midst of a real fire emergency, knowledge of the skills alone would not serve as an adequate deterrent to personal injury. It is appropriate, therefore, that training should emphasize the development of related motor components.

Cognitive Strategies and Motor Learning

Practice makes perfect; yet, there are instructional techniques which affect motor learning but which do not involve overt practice. Evidence is accumulating that the internal (i.e., cognitive) manipulation of imaginal representations of tasks can sometimes produce effects as powerful as those achieved by overt practice (Annett, 1985).

CAI does not provide learners with an opportunity to overtly practice motor skills. Yet, symbolic (audio-visual) representations of "real" world, motor behaviors can be modeled and/or simulated. Furthermore, the use of elaboration, feedback, and other specific instructional strategies provides opportunities for covert practice. It is with these methods that motor learning is facilitated. A rationale for how these constructs are incorporated into the CAI model used in this study follows.

Symbolic Modeling

Symbolic modeling (SM) was the logical outgrowth of documented effects of live modeling in therapy (Bandura, 1969; Geer & Turtletaub, 1967). It is quite likely that the cognitive processes identified as important in live modeling, such as verbal and imaginal coding and rehearsal (Bandura 1969) can, as well, occur as a function of observing filmed, videotaped, or computer-generated models. As Bandura and Barab (1973) point out, there is little reason to suspect that the symbolic processes are particularly different when based upon viewing a live versus filmed, or other artificially generated model.

Filmed, videotaped (and perhaps, although not nearly as well documented, computer animated) modeling has several advantages over live modeling. These advantages include:

(1) the ability to capture sequences that would be difficult to isolate in a natural setting; (2) providing a clinician or instructor with greater control and flexibility over the composition of the modeling scene; and (3) the convenient use of multiple models and/or repeated observations of the same model. In addition there is the benefit of efficiency. That is, more subjects can be treated in a clinical setting while demanding less personalized instruction (Thelen & Fry, 1979).

A number of variables and processes have been studied within the context of SM and have relevance to theoretical conceptualizations of modeling. The importance of model-observer similarity is one example which has drawn the attention of many researchers. Bandura and Barab (1973) looked at the relationship between model age and observer age. They found that adults showed as much snake-fear reduction after observing a child model as those who observed a peer model.

Kornhaber and Schroeder (1975) addressed this issue by exposing snake-fearing children to either a child or an adult model. Those children who observed a child model demonstrated greater fear reduction than those who observed an adult model. Thus, it appears that observations by adults of peer models or child models facilitates changes in behavior. However, the observation of adult models has minimal effects on children. Bandura and Barab (1973) suggest that children may see older models as superior and more capable and therefore, may not imitate their behaviors as much.

Bandura (1977) has emphasized the importance of attentional and imaginal-verbal cognitive processes in modeling. In order to imitate, the observer must first attend to critical model behaviors. Secondly, the cognitive processes of imagery labeling and verbal labeling that are sustained over time by rehearsal facilitate later imitation of a model when external cues are not present. Third, in order to overtly imitate a model, a person must have the motor reproduction abilities that are particularly relevant to more complex behavior. Last, although modeled behavior can be acquired by observation alone, reinforcement is critical if the observed behavior is to be performed and this performance is to be maintained over time.

Another variable that has received considerable attention is narration, or a description of the model behavior concurrent with model performance. Based on current theorizing, narration should facilitate attention to the model and verbal labeling of the model's critical behaviors. Thus, the effectiveness of modeling interventions should increase. Jakibchuk and Smeriglio (1976) reported that SM plus narration failed to significantly affect the social behavior of isolated preschool children in comparison with two control groups.

However, other researchers (Evers-Pasquale & Sherman, 1975; Keller & Carlson, 1974; Spiegler, Liebert, McMains, & Fernandez, 1969) report that SM plus narration diminishes snake fears in adults. Since SM alone often has a positive effect, it may be questionable to demonstrate that SM plus narration has a favorable effect. Perhaps the better inquiry is whether narration has an incremental effect on SM alone. On this question Morris, Spiegler, and Liebert (1974) found that SM plus narration was equal to SM alone, based on a self-report measure of snake fear among adolescents. In another study, Meichenbaum (1971) reported that a model's self verbalization facilitated reduction of snake fear among female undergraduates. It may be that self-verbalization (a type of narration in this context) facilitates the conversion of the model's behavior into perceptual-cognitive images as described by Bandura (1977).

The nature of the model context may be critical to attentional processes. The model context needs to be simple enough to insure attention, but contain enough contextual cues to encourage generalization to other settings. As the complexity of the target behaviors increases, there may be a need to both simplify and amplify the target behaviors.

There is relatively little research material available on the question of SM and its effects on retention. The benefits of rehearsal and practice components so frequently used in other behavioral research might be expected to facilitate not only the immediate imitation of a modeled behavior, but in long-term retention as well.

Visual learning

The visual perception ability of the learner is a critical component of all behavior modification facilitated through the use of symbolic modeling. From experimental psychology we know that a significant amount of effort is devoted to the problems of "getting information into long-term memory, keeping it there, retrieving it, and interpreting it properly" (Lindsay & Norman, 1972). The more interconnections that can be made between information, the more likely it is that a retrieval cue will be successful.

Paivio (1971) theorized that there are two separate, but interconnected memory systems -- one of which is verbal while the other is visual. Paivio's position that pictures are remembered better than words and words that can be imaged, are easier to remember than words which cannot be imaged, is supported by research (e.g., Levie & Levie, 1975). Although there is some disagreement about Paivio's dual-code theory, researchers generally agree that the systems do interact.

Although the question concerning a single versus dual-code memory system has not been fully resolved, the basic insights are most likely correct -- that pictures are processed more globally and in a non-linear fashion, whereas words must be held in a buffer until they can be interpreted in the intended context. For example, a picture may be scanned vertically, horizontally, etc., while searching for generalities or specific details whereas written or oral sentences cannot be correctly processed until all words have been presented (Dwyer, 1987). Thus, as Cermak (1972) explains, very little coding is required to retain picture images in memory. The type of encoding necessary for some words, and/or phrases takes more time to accomplish. Apparently, pictures can be represented immediately on a low level of interpretation.

Extensive research reported by Dwyer (1978) lends support for the use of visuals as worthwhile mediators for learning. Other researchers report that visuals improve learning of prose material (Dwyer & Parkhurst, 1982; Levie & Levie, 1975; Paivio & Csapo, 1969). Levie and Lesgold (1978) have shown that pictures improve comprehension.

McBride and Dwyer (1985) found that a positive relationship exists between the number of eye fixations and achievement scores, and that visual content which is chunked requires significantly less time for students to process. The results of this study and those cited above verify the importance of visualized instruction. If visualization strategies are properly embedded in instructional content (including those in a computerized environment), they have the potential to significantly increase student achievement and/or performance.

Elaboration

Elaboration is the term used for the process by which additional paths or links to information are made (Anderson, 1980). Elaboration uses connections to prior knowledge, imaging, and features from the current context to improve memory by increasing connections and imposing organizations of the information. This frequently occurs during mental rehearsal of such information. The point is that visual activity contributes significantly to the initial quantity and quality of information gathered.

The fact that the efficient and effective learner is mentally active in the learning process has been well documented (Bransford, 1979; Bruner, 1966; Travers, 1970). Travers (1970, p. 131) said "attention coupled with activities involving the utilization of information are likely to be much more successful." Appropriate learning activities, commensurate with learning objectives, can capture and maintain attention.

Lindsay and Norman (1972) have argued that the longer an item is maintained in short-term memory by rehearsal, the greater the probability that it will be retained. Rehearsal, therefore, can be considered an activity which can serve the learner in several ways including motivating and promoting further mental activity. Different rehearsal strategies involve different amounts of time and differ in intensity of learner involvement. Ideally, it would be beneficial if it could be determined which rehearsal methods (visual, verbal, overt) are most appropriate for use in specific instructional situations.

Craik and Tulving (1975) and Hyde and Jenkins (1969) reveal that what is remembered is a function of whether the learning task is structural or semantic in nature. If the interaction between the learner and the intended information lasts long enough, it can be elaborated upon and transferred to long-term memory. In addition, the rehearsal method chosen determines what type of elaboration will take place (Dwyer, 1987). As alluded to earlier, newer educational technologies such as the microcomputer can play a role both in memory research and for instructional purposes because of the potential it has for individualizing instruction and utilizing varied rehearsal and retrieval strategies.

If learners are expected to retrieve information, it must be encoded in a manner which facilitates retrieval. In other words, the type of encoding a stimulus receives has important consequences for its retrieval. Bransford (1979) and others (Tulving, 1979; Tulving & Osler, 1968; Watkins & Tuling, 1975) have indicated that the effectiveness of retrieval cues is related to the elaborateness of the encoding during the learning task. It is possible to control how much time students are permitted to view and/or interact with a visual presentation; however, the quality of the interaction which occurs cannot be controlled or evaluated directly while students are interacting.

Feedback

In a critical review of the literature on feedback and motor learning, Salmoni, Schmidt, and Walter (1984), found no evidence to convincingly contradict the idea that some informational feedback is critical for learning. They reported that frequency increases in knowledge of response (KR) enhance motor learning while KR also helps the learner to perform the proper response.

Instructional feedback appears to be most useful in the cognitive phase (Dul, Pieters, & Dijkstra, 1987). External feedback can help a learner to constrain choices to be made at any given time, and thus, limit the learner's degrees of freedom. The type of information selected by an instructor to return to the learner should correspond to the level of motor output in the learning process.

With the possible exception of overt rehearsal, feedback is generally viewed as the most important variable in the acquisition of motor skills (Bilodeau, 1966; Newell, 1977). What remains unclear is whether the methodology chosen to deliver feedback has some bearing upon its effects, especially in the area of motor learning. Of particular interest to this study is the methodology of CAI. Whereas a number of behavioral therapists have found certain types of media (e.g., films, tapes, videos) to be effective in motor skill development, the area of CAI, use of feedback, and motor development is relatively unresearched.

CAI and feedback

Computer feedback is any communication (visual or auditory) generated by a computer following a user's completion of a response (Steinberg, 1984). The role of instructional feedback is to compare actual learner performance with desired learner performance. When differences exist between the two, the learner is given the opportunity to reduce the difference. Thus, learning is facilitated.

Feedback has been recognized as an essential component of learning for many years (Kulhavy, 1977). From a cognitive perspective, the use of feedback in CAI has attracted the interest of numerous researchers (Cohen, 1985; Kulhavy, Yekovich, & Dyer, 1976; Siegel & Misselt, 1984; Mevarech & Ben-Artzi, 1987; Noonan, 1986; Surber & Leeder, 1988; Wager & Wager, 1985). These studies focus on the differences among learner outcomes as measured against a variety of feedback types used during CAI.

For example, Kulhavy (1977) found that, when high-confidence errors occur, feedback acts as a strong corrective device and tends to maintain itself over a retention interval. They concluded that varying a feedback procedure could yield substantial gains in learning. Wager and Wager (1985) found that delayed feedback produces better retention than immediate feedback. Cohen (1985) reported that delayed feedback facilitates the learning of more abstract and conceptual material in which higher thinking must be employed. He also reported that feedback after a correct response is not as important or facilitative to learning. Siegel and Misselt (1984) found that corrective feedback adjusted to the type of errors made by the learner was more effective than the fixed feedback usually provided in CAI environments. Rocklin and Thompson (1985) reported that immediate computer feedback facilitates performance, particularly on tests administered to highly anxious students.

Computers and Skill Development

Whether CAI is an appropriate substitute or supplement to present instructional methods used in fire-safety skills training is an empirical question. It is interesting to note, however, that a number of the instructional methods and components used in conventional fire-safety skills training parallel those used in CAI. Therefore, it is appropriate to explore these issues among current CAI research literature.

A general discussion on the use and effectiveness of the microcomputer as an instructional medium will be presented. Since the use of graphics and animation represent the CAI counterpart to behavioral, in vivo modeling, current research on these CAI tools will be included. Finally, the use of elaboration and feedback as they pertain to the acquisition and/or maintenance of skill will be discussed.

Early studies and CAI

Jamison et al. (1974) conducted one of the most comprehensive literature reviews ever done on CAI. These researchers studied the effects of CAI along with several other instructional media. After an examination and review of approximately 20 major studies, it was concluded that CAI-supplemental instruction is an effective teaching method at the elementary level. Furthermore, CAI-replacement instruction (i.e., compared to traditional instruction) is effective at secondary and college levels. Comparisons between supplemental and replacement methods were not made since CAI tended to be used as a supplement to instruction at lower levels and a replacement at higher levels. Jamison et al. (1974) found that younger children and students of lower ability seem to benefit more by CAI than any other group. Several findings pointing to time-savings in learning were also noted (Vinsonhaler & Bass, 1972).

Later, Edwards, Norton, Taylor, Weiss, and Dusseldorp (1975) reached some of the same conclusions as earlier reviewers, yet offered several new insights. For example, when comparing supplemental CAI versus replacement CAI, they found the former to be more effective. Learning time seemed to be lower in studies where the use of supplemental CAI was considered. However, retention of learning did not seem as high as with other traditional modes of instruction.

Thomas (1979) reviewed the use of CAI among non-elementary or secondary students. His review does not address supplemental versus replacement CAI. Yet, a majority of the studies on achievement cited in the review report equal or greater results when compared to traditional instruction. On the basis of the data reported, the factor most positively affected by CAI is a reduction in time to complete instruction. On the other hand, a review conducted by the Florida Department of Education (1980) cites "improved attitudes" as the most important factor to consider when using computer-based treatments.

Summarizing reviews of CAI literature up until 1980, the following conclusions can be made: (1) larger gains with CAI treatments occur more often at elementary grades that at higher grades; (2) equal achievement between computer-based and traditional treatments are the most prevalent finding; (3) supplemental CAI seems to result in more gains than replacement CAI; and (4) factors most positively affected by

CAI include reduced learning time and attitude toward instruction (Robyler, 1985).

CAI Research Since 1980

A number of CAI studies have been conducted since the turn of the decade. Perhaps the more widely known reviews are those of Kulik and his colleagues (Kulik, 1981; Kulik, Bangert, & Williams, 1983; Kulik & Kulik, 1985; Kulik, Kulik, & Cohen, 1980). Based on meta-analyses, they concluded that CAI effect sizes were smallest at the college level and greatest at the elementary level, with secondary level effect sizes falling in between.

Niemiec, Samson, Weinstein, and Walberg (1987) reviewed forty-eight studies conducted on CAI between 1971 and 1982. These studies focused on CAI in the elementary school and were coded on forty-five variables using meta-analytic techniques. Results indicated that younger and lower achieving students benefit most from exposure to CAI. Niemiec, et al. found that, in the typology of the computer's use in education, drill and practice provides the highest effect sizes.

Niemiec, et al. also found that when effect sizes were examined for longer versus short studies, there was a clear indication that treatment duration is an important variable. It appears that the longer the study progresses, the smaller the effect size becomes. They found that when the treatment continues for one semester to a full year, the effect size shrinks by 50 percent. Treatments less than, or equal to two months produce disproportionately high effect sizes, suggesting the possibility of a novelty or Hawthorn effect.

The kind of computer used in the investigation was the variable that generated the largest difference between studies. The majority of studies employed mini or mainframe computers. Only two were conducted using a microcomputer. This points to a definite need to conduct further research of this type using microcomputers to determine if these results can be replicated. Based upon their analysis, Niemiec, et al. found CAI to be an effective teaching method in elementary schools. Computers seem to enhance achievement when the learning task is relatively simple. In the elementary schools computers function most effectively, for example, in the learning of addition or multiplication facts. They are less effective when used in the development of math reasoning skills.

Graphics, Animation, and CAI

Graphics (*static* or *animated*) are widely accepted as having strong positive effects when used as visual learning aids (Suber & Leeder, 1988). Yet, the theoretical and empirical foundations for their use have **not** been solidly established (Rieber, 1990). Graphic learning aids naturally evolved from earlier instructional applications which employed *static* visuals (e.g., photographs, slides, filmstrips). Because of this, many practitioners have extended some of the conclusions drawn from research on *static* visuals to *animated* visuals when, in fact, it may be erroneous to do so. Unfortunately, few recent studies in *animated* visuals have dispelled this tendency by offering elaborations or exceptions to findings obtained in *still* visual research.

It is apparent from the frequent occurrence of graphics in instructional software that many CAI designers believe this type of visual aid serves as a facilitator, or motivator, for learning. It is unfortunate, however, that many of these claims are based upon anecdotal reports rather than systematic experimentation -- often times, the pyrotechnics of the medium contributing to its face validity. Ideally, the needs of the learner and the demands of the learning task should determine when, where, and what type of graphics are to be used for instructional purposes. Thus, empirical questions pertaining to the instructional effectiveness of graphics (either *still* or *animated*) used in CAI still need to be addressed.

Peters and Daiker (1982), in a study designed to investigate the facilitative effect of graphics on learning, could not find any significant, statistical differences between the control and experimental groups. These researchers suggested that the graphics used in their study may have failed to focus on the materials presented in the text and that they did not draw the learner's attention to certain contextual features.

Another study which failed to show the advantages of using graphics in learning was conducted by Reed (1985). According to Reed, one reason for his negative findings was that subjects failed to correctly perceive and interpret relevant information. Doll (1986) also failed to support her principal research hypothesis that interactive graphics would be an effective learning aid for elderly individuals. She partially attributed her findings to aspects of the experimental treatments. That is, she concluded that two few illustrations may have been used in presenting the material. Therefore, subjects were not provided with enough information pertaining to the content itself.

More promisingly, there are a few studies which report the positive effects of graphics on learning. For example, Rigney and Lutz (1976) and Alesandrini and Rigney (1981) reported the facilitative effects of using graphics in instruction that focused on recognition and recall learning. Baek and Layne (1988) found graphics to be an effective learning aid when used in conjunction with an explanation of the graphics (i.e., textual statements which addressed the relationship between the graphics being used and the concept or fact being taught). In their study, graphics produced higher performance scores than did text material. Also, animation used in this study produced higher performance scores than did either still graphics or text material alone.

Animated Graphics Research

Many non-experimental reports exist on animation and learning. However, few empirical studies have been conducted (Rieber, 1990). Examples of the more encouraging reports include those pertaining to animation and language activities (Withrow, 1978; Withrow, 1979), motion perception (Proffitt & Kaiser, 1986) and testing (Hale, Oakey, Shaw, & Burns, 1985). Nearly all of the empirical studies reported addressed the learning of facts, rules, and/or concepts and were limited to the cognitively-based disciplines of science and mathematics (Baek & Layne, 1988; Caraballo, 1985; King, 1975; Reed, 1985; Rieber, 1989a; Rieber, 1989b; Rieber, 1990; Rieber, Boyce, & Assad, 1990; Rigney & Lutz, 1975). Evidence of content validity and test reliability were reported in seven out of nine cases.

In the three experiments conducted by Rieber alone, elementary children were used as subjects. In two of these three studies, significant differences were reported; that is, "animated" graphics were more effective than "static" graphics in promoting specific learning outcomes (e.g., facts, rules, and problem solving skills). Rieber (1990) attributed the one exception to possible confounding resulting from lesson difficulty.

In the fourth study of which Rieber was a part (Rieber, et al., 1990), adults were used as subjects. Rieber and his colleagues reported no significant differences among learning outcomes based on the use of animated **versus** static graphics during instruction. However, the authors did report reductions in question response time, suggesting that animation aided the learners' retrieval and reconstruction processes during posttest.

Findings from most of the other investigations were similar. Baek and Layne (1988) reported that "animated" visuals were more effective than "static" visuals, which in turn, were more effective than "text" visuals when teaching mathematical rules to high-school students. Rigney, et al. (1975) reported preferences for pictorial **versus** verbal instruction, yet provided no control for static **versus** animated visuals during training.

Only two of the above mentioned studies reported no significant differences in their findings. King (1975) attributed this to a lack of difficulty in the learning task. Caraballo's (1985) findings, although presented as conclusive, lacked validation to determine if additional visuals were needed.

Baek and Layne (1988) identified several points to be considered when studying the effectiveness of graphics in computer based learning. First, a definition of terms needs to be clarified (e.g., *animated vs static*). Secondly, a careful use of graphics to draw student attention is required; that is, the graphics used should emphasize the important features of the material being presented. Thirdly, when graphics are included in instructional materials, it is useful to first remove any possible misconceptions regarding their use, and help students notice that the characteristics of the graphics are related to the subject matter. Fourthly, when studying the effectiveness of graphics in CAI, the content of the passage needs to be considered.

Summary

Systematic approaches to learning have placed a demand on researchers to conduct more detailed analyses of instructional media. Thus, interpretation of research pertaining to graphics, animation, and learning should be approached cautiously and prudently. The few serious attempts to empirically investigate this instructional medium have yielded inconsistent results. Therefore, it is imperative that more accurate and adequate prescriptions for subsequent research be established.

Furthermore, based upon the extant research literature, there is no doubt that further empirical investigations in graphics (*still* or *animated*) and CAI are warranted. Studies which focus on long-term effects, or identifying subject areas in which graphics can be effectively applied, represent two possibilities. Also, studies that look at the attributes of the medium, rather than the interrelationships between it and other kinds of instructional media, are relevant research topics.

Hypotheses

This research was designed to assess the influence of behavioral and computerized training strategies on the acquisition and knowledge of fire-safety skills in a population of school-aged children. Three trained groups, (1) Behavioral; (2) Animated-Graphics; and (3) Still-Graphics were compared with an untrained group, (4) Control.

First, it was hypothesized that, at posttest, children in the Behavioral, Animated-Graphics, and Still-Graphics groups would show greater levels of knowledge, and performance of fire-safety skills than children in the Control group.

Secondly, it was hypothesized that, at posttest, children in the Behavioral group would show levels of knowledge and performance of fire-safety skills equivalent to that of children in the Animated-Graphics group.

Thirdly, it was hypothesized that, at posttest, children in the Animated-Graphics group would show greater levels of knowledge and performance of fire-safety skills than children in the Still-Graphics group.

Chapter 3—Methodology

Subjects

In a small university community in southwestern Virginia, 56 children (21 boys and 35 girls) from middle-class neighborhoods participated in the study. All children were enrolled in fourth grade (ranging in age from 9-10) and were randomly assigned to one of four groups: (1) Behavioral, N = 14; (2) Animated-Graphics, N = 13; (3) Still-Graphics, N = 15; and (4) Control, N = 15. Parental permission was also obtained.

Setting and Apparatus

All training was conducted in rooms within the school. A total of four rooms were converted to simulated "bedrooms" for behavioral assessment and/or training. The following equipment was provided for each room: a cot, chair, rug, E-Z tilt window, and a door. Computerized components of training were conducted in rooms containing a table, chair and microcomputer.

Software Development

All computer software programs were written by the author and tailored for an IBM (or compatible) system configured with a 8088 microprocessor, standard keyboard, graphics adapter card (CGA or monochrome), and maintained on two, five and one-quarter (5-1/4) inch diskettes. The presentation and animated components of all software were written using PC/PILOT (Washington Computer Services, v 3.01). All graphic images were developed with PC PAINTBRUSH (Zsoft Corporation, v 2.01) and captured with the "Freeze" utility.

Social Validation

In an article published by Jones, et al. (1981), nine simulated, fire-emergency situations were described as model environments in which he and his colleagues conducted fire-safety, emergency skill training. All situations were validated by expert judges and fire fighters. One of the nine situations, "Nothing blocking the path", was used in this study.

Pre-training Assessment

Pre-treatment assessment occurred in two phases: (1) knowledge (questionnaire) assessment; and (2) behavioral, or skill assessment. During phase one, all children were administered the Behavioral Skills Questionnaire, BSQ, (Jones & Randall, 1988), and the Elaboration for Behavioral Skills Inventory, EBSI, (Jones, 1984) as measures of fire-safety-skill knowledge. The Behavioral Observation Checklist, BOC, was used to assess skill performance. Pyschometric validity data (i.e., test/re-test = .80) was also available for the BSQ.

Knowledge

The **BSQ** is an open-ended inventory consisting of four questions (See Appendix A). Examples of questions include: "If you smelled smoke at night when you were in bed, tell me what you think you would do?", "If your bedroom door was hot? (what do you think you would do?)", and so on. Children were awarded one point for each correct answer as judged by a trained evaluator.

The **EBSI** is also an open-ended inventory. This inventory (See Appendix B) consists of ten questions, examples of which include: "Why should you roll out of bed and get into a crawl position?", "Why should you feel the bottom of the door?", and "Why should you feel the top of the door?" Children were awarded one point for each correctly answered question as judged by a trained evaluator.

Skill

In phase two of the pre-treatment assessment a short, narrative description (i.e., "Let's pretend it is late at night; you are lying in bed, and you smell smoke in your room. You are not coughing and your eyes are not burning") of the emergency situation, "Nothing blocking the path," was read aloud to each child by trained observers. Afterwards, children were presented a verbal, sensory cue (e.g., "Your eyes are not burning, and you are not coughing. You hear a smoke alarm . . ."). and were asked to demonstrate what they would do if the situation just described represented a real, fire emergency. Each child's performance was evaluated by trained observers; that is, skill execution was judged against a series of behavioral steps specified in the Behavioral Observation Checklist (See Appendix C).

Examples of items in the BOC include: "Rolls or slides out of bed and onto the floor (does not sit up for more than five seconds)"; "Gets in crawl position (both hands and knees) after getting out of bed (before walking more than one step). Subject may sit down on the floor before actually getting in a crawl position with hands and knees on the floor"; "Crawls directly from bed to door (using hands and knees)". Children earned one point for each correctly performed response. A response was deemed correct if done properly <u>and</u> in sequence. Correct responses performed out-of-sequence did <u>not</u> receive credit. The child's final score was obtained by calculating the percentage of correct responses; that is, by adding up the total number of correct responses for the situation, dividing that number by the total number of possible correct responses, and finally, multiplying that number by 100 in order to obtain a percentage.

Post-Training Assessment

Immediately following the last training session per group, the children underwent post-assessment. They were assessed in both knowledge and skill exactly as they had been prior to treatment.

Reliability of Assessment

A group of undergraduates were trained over a two-week period to serve as assessors (See Appendix D). Their training consisted of modeling, role playing, corrective feedback, social reinforcement, and behavioral practice. Questionnaires used in the study were administered by trained undergraduates, yet evaluated by this author. Reliability checks on the behavioral data were taken during 30% of the pre- and post- tests. Subsequently, an inter-rater reliability (89%) was calculated from this data by dividing the number of agreements by the sum total of agreements and disagreements and multiplying by 100 to form a percentage.

Procedures

After pretest, children were randomly assigned to one of four groups: (1) Behavioral; (2) Animated-Graphics; (3) Still-Graphics; and (4) Control. Training was held on two consecutive days with each training session lasting from 25-30 minutes. Children were trained in groups of three, with each child undergoing four phases of instruction: (1) demonstration; (2) practice; (3) elaboration; and (4) review. Table 1 summarizes the teaching methods used per

Table 1. Instructional Method Per Phase Per Group

Training Phase	**GROUP**		
	Behavioral	Animated	Still
Demonstration	Animated Graphics Modeling	Animated Graphics Modeling	Still Graphics Modeling
Practice	Behavioral Rehearsal w/ In-vivo Feedback	Multiple Animated Graphic Viewings	Multiple Still Graphic Viewings
Elaboration	Oral, In-vivo Discussion Feedback	Interactive Computerized Tutorial w/ Feedback	Interactive Computerized Tutorial w/ Feedback
Review	Repeat All Phases	Repeat All Phases	Repeat All Phases

Note: Control Group received no training.

group for each phase of the training. A more detailed desciription follows.

Behavioral Group -- Demonstration

In the behavioral group, children watched a computer program which displayed an animated caricature (named "Joey") modeling the skills associated with the selected fire-emergency situation. The sequence of animated movements paralleled the steps enumerated in the Behavioral Observation Checklist (See Appendix E). Each animated scene included a static text caption describing its content. The first image shown was a text narrative explaining the context of the situation and objectives of the instructional unit. Subsequent graphic animations were as follows:

Animation 1:	Joey's sliding out of bed onto the floor.
Animation 2:	Joey's getting on both hands and knees, facing the door.
Animation 3:	Joey's crawling directly from the bed to the door, using hands and knees
Animation 4:	Joey's lifting one hand, placing it on the bottom of the door. Subsequently, Joey's standing up, and feeling the upper part of the door with the back portion of the hand.
Animation 5:	Joey's returning to the crawl (or squat) position.
Animation 6:	Joey's bracing the door with one foot, keeping one knee on the floor, and placing a hand in front of the crack; also, Joey's opening of the door

slightly.

Animation 7: Joey's opening the door completely while remaining in the crawl squat or crawl position.

Animation 8: Joey's going outside the bedroom door while remaining in a squat position

Animation 9: Joey's closing the door.

Animation 10: Joey's crawling to the stair and going down the stairs backwards.

Animation 11: Joey's crawling to the outside door and going outside.

Behavioral Group-Practice

In this phase of training each child in the behavioral group was given the opportunity to overtly practice the steps viewed during the computer animations. As the trainer verbalized the steps, (e.g., "Roll or slide out of bed", "Now get on both hands and knees, facing the door", and so on) the children were asked to perform each one.

At the end of each correctly performed step, children immediately received knowledge of response (KR) feedback (e.g., "That's correct," or "Good!"). If the child's first attempt was incorrect, the trainer would also provide knowledge of the response plus corrective feedback. Corrective feedback consisted of verbal instructions regarding adjustments for the child to make, or the trainer's modeling the correct behavior, or both.

If a second attempt to correctly perform the steps failed, the trainer provided feedback as before. If the child failed an attempt for the third time, the trainer simply stated the correct behavior and moved on to the next step in the sequence.

Behavioral Group-Elaboration

In this phase of the training, children were presented questions pertaining to the rationale for each step in the target skills. Examples included, "Why should you roll out of bed and get into a crawl position?", "Why should you feel the bottom of the door?", "Why should you feel the top of the door?", "Why should you use the back of your hand when feeling the door?", and so on (See Appendix F). Following the reading of each question a list of possible answers were read aloud. For example, in reference to the first question, the following were offered as possible responses: "(a) to day quiet so no one can hear you; (b) staying low will keep you near the blanket for cover; (c) staying low helps you to see and breathe better; and (4) rolling out of bed and crawling is easier than walking." After the choices were read, children were given an opportunity to respond to the trainer by stating his/her answer.

After the child's verbal response, the trainer provided KR feedback (e.g., "That's correct," or "No, that is not correct."), followed by additional rationale information pertaining to the step (e.g., "Firemen tell us that staying low keeps us close to the floor where there is more air to breathe," in response to question 1, or "Firemen tell us that you should feel the bottom of the door to see if the bottom of the door is hot", in response to question 2).

Lastly, children were asked to complete a multiple-choice test in writing (See Appendix G). The test consisted of the same questions which were read aloud previously. Trainers corrected the test and reviewed the scores with the children as a means of providing additional feedback and/or learning reinforcement.

Behavioral Group-Review

For review, children in the Behavioral Group repeated one complete cycle of the practice and elaboration phases of training.

Animated-Graphics Group-Demonstration

Children in the Animated-Graphics group viewed the steps in exactly the same manner as children in the Behavioral group (See Appendix H).

Animated-Graphics Group-Practice

As a substitute for overt practice, children in the Animated-Graphics group were given two opportunities to covertly, or mentally rehearse the steps presented during the animation. That is, the computer program was repeated two times, with children advancing from scene-to-scene through interaction with the keyboard (i.e., pressing the "return" key).

Prior to each animated step, a prompt was displayed on the screen. For example, "If you're in bed late at night and you hear a smoke alarm, what is the first thing you should do?" was displayed just before the first animation. Following each prompt, the program paused, allowing children to respond to a set of multiple-choice options. For example, in response to question one, choices included: "(a) sit on the edge of the bed; (b) roll or slide out of bed; (c) hide under the blanket; and (d) run to the window right away."

Children were given three opportunities to correctly respond to each prompt. Correct and incorrect responses were handled in much the same manner as they were in the Behavioral Group. That is, knowledge of response feedback (e.g., "That's right," or "Wrong choice! Watch closely and try again") was controlled and presented by the computer. If a prompt was answered incorrectly, a control loop in the program re-routed the child to the animated sequence referenced in the question, at which time, the child viewed the animation again. If the child missed the question three consecutive times, the program displayed the reference animation once more, yet moved on to the next sequence in the scenario.

Animated-Graphics Group -- Elaboration

During this phase of the training, children in the Animated-Graphics group were asked to respond to the same questions given to the Behavioral group. However, questions were presented, tracked, and evaluated via the computer. Correct responses were followed by the same additional, rationale information presented to the Behavioral group, yet in a computerized format (i.e., screen text). Children were asked to read all text screens out loud; that is, identical to the manner in which children in the Behavioral group verbalized each statement.

Children were required to "key" in their responses. Elaboration test scores were tabulated by the computer and revealed to the child at the completion of the exercise. This interactivity served as the counter-part to the written elaboration test conducted in the Behavioral Group.

Animated-Graphics Group -- Review

For review, children in the Animated Group repeated one complete cycle of all phases of training.

Still-Graphics Group

All phases of training in this group were identical to those of the Animated-Graphics group with one main exception noted. That is, no animation was used in either the initial modeling, nor in subsequent opportunities to practice or elaborate. Instead, "before" and "after" still images were displayed on the computer screen. Consequently, children were forced to imagine the details of the transition or remain oblivious to them all together.

Control Group

Children in this group received no training whatsoever.

Chapter 4—Results

Overview

The data were analyzed by employing a series of 4 x 2 ANOVAs, analysis of covariance, and Student-Newman-Keuls tests. Three assessment instruments were employed as dependent measures for skill and/or knowledge acquisition. The Behavioral Observation Checklist, BOC, was used to assess skill, while the Behavioral Skills Questionnaire, BSQ, and the Elaboration for Behavioral Skills Inventory, EBSI, were used to assess knowledge.

Skill

First, the effect of various training methods on the acquisition of fire-emergency skills was examined. Three training groups, plus a control group were compared. Groups were categorized according to the instructional methodology used therein and were named as follows: (1) Behavioral; (2) Animated-Graphics; (3) Still-Graphics; and (4) Control. Target skills included "rolling out of bed", "crawling to the door," "opening the door while bracing it with foot and knee," and so on.

Behavioral Observation Checklist, BOC

BOC pretest and posttest means, plus standard deviations were calculated for Groups 1 through 4, and are shown in Table 2. A graphical representation of these means can be found in Appendix I. Pretest mean scores ranged from a low of 0.40 (Group 3) to a high of 1.57 (Group 4). Student-Newman-Keuls pretest analysis indicated that the average skill performance of the Control group ($\underline{X}$ = 1.57) was significantly higher ($p < .05$) than performance among the remaining three groups. To compensate for this, an adjusted F value was computed using analysis of covariance (ANCOVA). Thus, the influence of pretest differences (i.e., the covariate) on subsequent measures was reduced, or eliminated all together. Table 3 shows the results of the ANCOVA [F (3,1) = 76.72, $p < .0001$] which confirmed subsequent analyses by providing increased precision in determining the effect of training method on the acquisition of behavioral skills.

BOC posttest mean scores ranged from 1.36 (Control) to 11.0 (Behavioral). These means (see Table 2) indicated that the Behavioral ($\underline{X}$ = 11.0), Animated ($\underline{X}$ = 5.85), and Still ($\underline{X}$ = 2.93) groups experienced gains in skill performance while the Control group ($\underline{X}$ = 1.36) did not. Rather, a decline in the Control group's mean performance was observed. Differences in group means were also tested for significance using a 4-Groups (Behavioral, Animated, Still, and Control) X 2-Phase (Pre, Post) ANOVA. Results of the ANOVA are shown in Table 4. The ANOVA revealed significant main effects for both Group [F (3,52) = 26.81, $p < .0001$] and Phase [F (1,52)

Table 2. Group Means and SD - Behavioral Observation Checklist

GROUP	PRETEST	SD	POSTTEST	SD
Behavioral	0.43	0.65	11.00	0.00
Animated	0.92	1.32	5.85	3.46
Still	0.40	0.83	2.93	2.12
Control	1.57	1.50	1.36	1.39

Behavioral (pre: N = 14; post: N = 14)

Animated-Graphics (pre: N = 13; post: N = 13)

Still-Graphics (pre: N = 15; post: N = 15)

Control (pre: N = 14; post: N = 14)

SD = Standard Deviation

Note: Maximum score on pre and posttest = 11.0

Table 3. Univariate Repeated Measures Analysis of Covariance

MEASURE	GROUP F	P	CoVar	P
BOC	76.72	.0001*	19.20	.0001*
EBSI	43.54	.0001*	9.01	.0042*

BOC = Behavioral Observation Checklist

EBSI = Elaboration for Behavioral Skills Inventory

F = F test

P = P value

* = Significant

Table 4. Univariate Repeated Measures Analysis of Variance BOC, BSQ, and EBSI

MEASURE	GROUP F	P	TIME F	P	INT F	P
BOC	26.81	.0001*	341.99	.0001*	91.29	.0001*
BSQ	3.08	.03	37.76	.0001*	9.47	.0001*
EBSI	15.54	.0001*	189.99	.0001*	11.41	.0001*

BOC = Behavioral Observation Checklist

BSQ = Behavioral Skills Questionnaire

EBSI = Elaboration for Behavioral Skills Inventory

F = F test

P = P value

* = Significant

= 341.99, $p < .0001$] which was qualified by a significant Group X Phase interaction [F (3,52) = 91.29, $p < .0001$).

Student-Newman-Keuls tests performed on **unadjusted**, posttest means, substantiated differences among the groups. Skill measures for both the Behavioral and Animated groups were significantly better than that of Still and Control groups, with analyses indicating no differences among the latter two. Moreover, posttest Student-Newman-Keuls analyses applied to **adjusted** means indicated that all treatment groups performed significantly better than the control group. In addition, the Behavioral group out-performed the Animated group, which in turn, did significantly better than the Still group.

Knowledge

Secondly, the effect of various training methods on knowledge attainment was examined. Two questionnaires served as dependent measures: (1) The Behavioral Skills Questionnaire (BSQ); and (2) Elaboration for Behavioral Skills Inventory (EBSI).

Behavioral Skills Questionnaire

BSQ pretest and posttest means, plus standard deviations were calculated for Groups 1 through 4, and are shown in Table 5. A graphical representation of these means can be found in Appendix I. Pretest means ranged from a low

Table 5. Group Means and SD - Behavioral Skills Questionnaire

GROUP	PRETEST	SD	POSTTEST	SD
Behavioral	0.64	.74	2.50	1.45
Animated	0.69	.85	3.00	1.47
Still	1.53	1.18	2.27	1.44
Control	1.07	1.07	0.78	0.95

Behavioral (pre: N = 14; post: N = 14)

Animated-Graphics (pre: N = 13; post: N = 13)

Still-Graphics (pre: N = 15; post: N = 15)

Control (pre: N = 14; post: N = 14)

SD = Standard Deviation

Note: Maximum pre- posttest score = 4.0

of 0.64 (Behavioral) to a high of 1.53 (Still). Student-Newman-Keuls analysis performed on pretest measures showed no differences among the groups.

Means on posttest scores ranged from 0.78 (Control) to3.0 (Animated). Student-Newman-Keuls analysis indicated that knowledge acquisition for the Behavioral ($\underline{X}$ = 2.5), Animated ($\underline{X}$ = 3.0), and Still ($\underline{X}$ = 2.27) groups was significantly better than that of the Control group ($\underline{X}$ = 0.78). However, when compared to each other, training methods used in all treatment groups were equally effective in promoting knowledge acquisition.

A 4-Groups (Behavioral, Animated, Still, and Control) X 2-Phase (Pre, Post) ANOVA revealed significant main effects for both Group [$\underline{F}$ (3,52) = 3.08, $\underline{p}$ < .03) and Phase [$\underline{F}$ (1,52) = 37.76, $\underline{p}$ < .0001) which was qualified by a significant Group X Phase interaction [$\underline{F}$ (3,520 = 9.47, $\underline{p}$ < .0001).

The Elaboration for Behavioral Skills Inventory, EBSI

This inventory served as a second dependent measure for knowledge acquisition. As with previous measures, group means, along with their standard deviations, were tabulated and are shown in Table 6. A graphical representation of these means can be found in Appendix I. Pretest Student-Newman-Keuls analysis indicated differences among group performance. That is, the Behavioral ($\underline{X}$ = 4.57) and Animated

Table 6. Group Means and SD - Elaboration of Behavioral Skills Inventory

GROUP	PRETEST	SD	POSTTEST	SD
Behavioral	4.57	2.24	9.78	0.43
Animated	5.53	2.22	9.38	0.96
Still	3.33	2.22	8.53	1.59
Control	3.28	1.98	4.50	2.21

Behavioral (pre: N = 14; post: N = 14)

Animated-Graphics (pre: N = 13; post: N = 13)

Still-Graphics (pre: N = 15; post: N = 15)

Control (pre: N = 14; post: N = 14)

SD = Standard Deviation

Note: Maximum pre- posttest score = 10.0

($\underline{X}$ = 5.53) groups performed significantly better on the measure than did both the Still ($\underline{X}$ = 3.33) and Control ($\underline{X}$ = 3.28) group. These initial differences were adjusted in a subsequent analysis of covariance which provided increased precision [$\underline{F}$ (3,1) = 43.54, $\underline{p}$ < .0001, see Table 3] in determining the effect of training method on the acquisition of safety-skill knowledge.

A 4-Groups (Behavioral, Animated, Still, and Control) X 2-Phase (Pre, Post) ANOVA (see Table 4) revealed significant main effects for both Group [$\underline{F}$ (3,52) = 15.54, $\underline{p}$ < .0001] and Phase [$\underline{F}$ (1,52) = 189.99, $\underline{p}$ < .0001) which was qualified by a significant Group X Phase interaction [$\underline{F}$ (3,52) = 11.41, $\underline{p}$ < .0001].

Student-Newman-Keuls posttest analysis on unadjusted, EBSI means indicated that the Behavioral 1 ($\underline{X}$ = 9.78), Animated ($\underline{X}$ = 9.38), and Still ($\underline{X}$ = 8.53) groups gained significantly more knowledge than the Control group. However, the same analysis revealed no differences among the treatment groups themselves. That is, similar to the first knowledge measure (BSQ), all training methods were equally effective in promoting safety-skill knowledge among the children.

Student-Newman-Keuls tests applied to adjusted EBSI means indicated that the Behavioral and Animated groups were equally effective in promoting knowledge acquisition. Both Groups the Behavioral and Animated groups did significantly better than the Control group, while all three treatment groups out-performed the Control group.

Chapter 5—Discussion

Overview

This study investigated two computer-graphics variations and their effectiveness on the acquisition of fire-safety knowledge and skills. Whereas previous research findings (Jones et al., 1989; Williams & Jones, 1989) have demonstrated that overt, behavioral modeling and elaborative rehearsal techniques are successful training strategies to use in the development of such skills, this study also examined the extent to which CAI graphics techniques could function either as a **supplement** or **substitute** to these earlier proven methods.

The most noteworthy findings were as follows: First, fire-safety skills can be acquired through the use of CAI graphics techniques. This finding held true when CAI was used either as a **supplement** or a **substitute** to behaviorally oriented training. Secondly, CAI graphics functioned better as a behavioral training **supplement**, rather than as a **substitute**. Thirdly, when comparing CAI "still" graphics to CAI "animated" graphics, "animated" graphics were more effective in helping children acquire fire-safety skills.

Skill-Cognitive Rationale

This study gave children opportunities to process information presented to them in a variety of forms (computerized and in-vivo). As a result, auditory and visual stimuli varied considerably across groups. It may be reasonably assumed, although not specifically supported by the data, that the children's depth of mental processing also varied, and may have been partially contingent upon the format of presentation. That is, depending upon the training method used, children may have gathered and cognitively processed additional bits of information (either sensory-motor, or verbal) which, potentially, could have affected the learning process.

Generally, the findings in this study supported findings from previous studies regarding the effectiveness of cognitively-based strategies which aid motor skill development (Adams, 1987). The findings were also consistent with previous research regarding the role observation plays in the acquisition and development of motor skills (Bandura, 1973).

Results of this study supported the original hypothesis pertaining to "animated" versus "still" graphics and can also be explained using Bandura's principles. The focus of Bandura's theory is that individuals learn from observing models in the natural setting. Bandura argues that key elements in designing instruction include (1) providing an appropriate model; (2) establishing the functional value of the behavior; (3) including opportunities for coding the observed behaviors into visual images or symbols; and (4) mentally rehearsing the modeled behaviors.

One possible explanation is that the characteristics of the "animated" training group more closely paralleled those of a natural setting -- perhaps the most significant factor being that of "movement". The movement alone, may have resulted in a greater number of eye fixations on the part of the observer and generated a higher degree of attentiveness to the learning medium. Consequently, in comparison to the Still-Graphics group, children in the Animated-Graphics group may have had more opportunities for encoding of stimuli to occur.

It is also possible that children were more attentive to the specific features of the icons and symbols used in the animated graphics group due to "game-like" nature of the presentation. That is, specific aspects of each step were deliberately exaggerated in the computer model in order to enhance the probability that children would pay closer attention.

Skill-Behavioral Rationale

One possible explanation for the superior performance among the Behavioral group was that "physical" stimuli were presented during practice. That is, during practice sessions, children were afforded the opportunity to receive and process additional sensory cues (e.g., touch, flexing of muscles) which, in turn, may have positively affected the learning which occurred.

It was clear from this investigation that training methods which heavily incorporate a behavioral component promote optimum fire-safety skill acquisition. This finding is with consistent with previous research regarding the role of overt practice in the acquisition and development of behavioral skills. Since the performance of fire-safety skills requires much bodily movement, it was not surprising to observe the relationship between motor training methodologies used in this study and the resulting learning outcomes.

Knowledge Rationale

All three treatment groups performed similarly with regard to the knowledge variable. Each, however, exceeded that of the control group. A possible explanation for this similarity is that knowledge content was presented in a similar fashion across all groups. Verbal methods (i.e., reading questions aloud, selecting responses from a list of choices, and responding to feedback) were basically the same for all groups. It would appear from the analysis of the data that the choice of instructional medium is not a factor in determining knowledge outcomes. Further investigation, however, would be necessary to substantiate this conclusion.

Conclusions

The findings of this study stand alone and can be justified from the data obtained. However, the author wishes to note that with a larger population from which to select a sample, more advanced hardware/software, etc., allowances could be made in the experimental design which could address research questions outside the scope of the present study. These concerns constitute embellishments for follow-up research and are based upon an assumption that the same physical constraints imposed upon this study (e.g., time, money, sample size) will be further reduced, or eliminated all together.

Findings of this study also support previous research which notes the superiority of behavioral teaching methods when used in cognitive-behavioral skills development (Jones, et al., 1989). Perhaps of greater significance is the finding concerning the impact of animated graphics, particularly with regard to its use in CAI when applied to the development of cognitive-behavioral skills, in general, and fire-safety skills in particular. CAI animated-graphic techniques are effective as an alternative or supplement to traditional behavioral methods used in fire-safety training. Potential benefits include (1) reduction in trainer preparation time; (2) reduction in implementation costs; (3) a vehicle for widespread distribution of training; and (4) more standardization with regard to instructional delivery and assessment.

This study can be regarded as an appropriate "next-step" in building upon the extant research literature on the use of graphics in CAI. Indeed, the potential benefits are promising. Moreover, it is hoped a greater understanding of how this medium of instruction can aid in the development of fire-safety skills and other types of motor learning will emerge. Further research efforts are warranted.

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APPENDIX A:

BEHAVIORAL SKILLS QUESTIONNAIRE

Appendix A
The Behavioral Skills Questionnaire

Date: ______________________________

Rater's Name: ______________________________

Subject's Name: ______________________________

Subject's ID No: ____________

Directions:

Read each question aloud; then pause for response.

Note to Rater: Record each subject's response(s). Allow 25 seconds maximum for subject to respond. If no response after 25 seconds, proceed to next question.

1. If you smelled smoke at night when you were in bed, tell what you would do.

2. Tell me what you would do if your bedroom door was hot.

3. Tell me what you would do if your bedroom door was cool.

4. Tell me what you would do if you opened the bedroom door and nothing was blocking your path.

APPENDIX B:

ELABORATION FOR BEHAVIORAL SKILLS INVENTORY

Appendix B. Elaboration for Behvarioal Skills Inventory

Situation 1: Nothing Blocking Your Path:

1. Why should you roll out of bed and get into a crawl position?
2. Why should you feel the bottom of the door?
3. Why should you feel the top of the door?
4. Why should you use the back of your hand when feeling the door?
5. Why should you get back into a crawl position?
6. Why should you brace the door and open it only a crack?
7. Why should you feel the air?
8. Why should you close the door behind you?
9. Why should you crawl to the stairs and go down backwards?
10. Why should you crawl to the outside of your house?

APPENDIX C:

BEHAVIORAL OBSERVATION CHECKLIST

Appendix C. Behavioral Observation Checklist

Date: ______________________________

Rater: ______________________________

Subject's Name: ______________________________

Age: ____________ Birthday ____________

ID NO: ____________ Teacher/Room ____________

Legend:

S=Sequence; O=Occurrence; X=Wrong; DP=Did Not Perform.

1. Rolls or slides out of bed and onto the floor does not sit up for more than five seconds) S O X DP

2. Gets in crawl position (both hands and knees) after getting out of bed (before walking more than one step). Subject may sit down of the floor before actually getting in a crawl position with hands and knees on the floor. S O X DP

3. Crawls directly from bed to door (using hands and knees). S O X DP

4. Lifts one hand, places it on bottom of door (has one knee on floor). Stands up and places hand on upper part of door. Note: Subject must use the back of hand when feeling the door. S O X DP

5. Returns to crawl position (or squat; i.e., knees bent). S O X DP

6. Braces door with one foot, keeping one knee on floor and placing a hand in front of crack; opens door one to two inches (not more than three inches) slowly. S O X DP

7. Opens door further than one or two inches (from "crawl" or "squat" position"). S O X DP

8. Goes outside bedroom door in "crawl" or "squat" position. S O X DP

9. Closes door. S O X DP

10. Crawls to the stairs and goes down backwards. S O X DP

11. Crawls to the outside door and goes outside S O X DP

APPENDIX D:
ASSESSOR'S SCRIPT

Appendix D. Assessor's Script

Date: ______________________________

Rater: ______________________________

Subject's Name: ______________________________

Age: ______________ Birthday ______________

ID NO: ______________ Teacher/Room ______________

Legend:

S=Sequence; O=Occurrence; X=Wrong; DP=Did Not Perform.

1. Rolls or slides out of bed and onto the floor does not sit up for more than five seconds) S O X DP

2. Gets in crawl position (both hands and knees) after getting out of bed (before walking more than one step). Subject may sit down of the floor before actually getting in a crawl position with hands and knees on the floor. S O X DP

3. Crawls directly from bed to door (using hands and knees). S O X DP

4. Lifts one hand, places it on bottom of door (has one knee on floor). Stands up and places hand on upper part of door. Note: Subject must use the back of hand when feeling the door. S O X DP

5. Returns to crawl position (or squat; i.e., knees bent). S O X DP

6. Braces door with one foot, keeping one knee on floor and placing a hand in front of crack; opens door one to two inches (not more than three inches) slowly. S O X DP

7. Opens door further than one or two inches (from "crawl" or "squat" position"). S O X DP

8.	Goes outside bedroom door in "crawl" or "squat" position.	S	O	X	DP
9.	Closes door.	S	O	X	DP
10.	Crawls to the stairs and goes down backwards.	S	O	X	DP
11.	Crawls to the outside door and goes outside	S	O	X	DP

APPENDIX E:

BEHAVIORAL GROUP TRAINING SCRIPT

Appendix E. Behavioral Group Training Script

Session Time Limit: 45 Minutes

1. Orientation

Trainer states the following:

"Each of you has been selected to participated in our special fire safety project. We'll be meeting for a few hours to learn more about fire safety. After we finish you will be tested to see how much you have learned. In order for you to learn everything you must pay close attention. Since we will be doing a lot of crawling, you should wear jeans. We have found that other boys and girls like yourself have really enjoyed this project. I think you will too!"

2. Get Each Subject's Name

3. Modeling

Use the computer to demonstrate steps 1-11 for situation 1 ("Nothing blocking the path"). Note: To start the program (assumes computer is turned on and contains correct diskettes in drives A and B):

   a. Type "START"
   b. Press the RETURN/ENTER key
   c. Type in the subject's first name
   d. Press the RETURN/ENTER key

Have subject(s) read the introduction out loud.

Obey screen prompts thereafter.

4. Rehearsal

Trainer states:

> "Now I want each of you to rehearse two times. Wait until I ask you what to do next, before you do the next step."
>
> "O.K., there is just a little smoke in your room. You are not coughing and your eyes are not burning. You hear a smoke detector, bzzzzzzzz...

Note: Have subjects say and perform responses simultaneously.

"Show me what you would do first"

a) Roll or slides out of bed onto the floor.

"Show me what you would do next"

b) Gets into a crawl position on all fours.

"Show me what you would do next"

c) Crawl directly from bed to the bedroom door.

"Show me what you would do next"

d) Lift one hand and feel bottom of door with the back of hand

"Show me what you would do next"

e) Stands up and feel the top of the door with the back of hand.

"Show me what you would do next"

f) Return to a crawl position.

"Show me what you would do next"

g) Brace the door

- with one foot on the door
- one knee on the floor
- and hand on the door knob

"Show me what you would do next"

h) Turn the doorknob and open the door just a crack.

"Show me what you would do next"

i) Place one hand in front of the crack while still bracing the door with other hand.

"Show me what you would do next"

j) Opens the door further from crawl or squat position.

"Show me what you would do next"

k) Crawls outside of the bedroom.

"Show me what you would do next"

l) Close the bedroom door.

"Show me what you would do next"

m) Crawls to the stairs to get to the outside door. (When at stairs, crawl down backwards.)

"Show me what you would do next"

n) Crawls to the door and opens the outside door.

REPEAT Steps A-N for second practice trial.

APPENDIX F:

ORAL REHEARSAL ELABORATION

Appendix F. Oral Rehearsal Elaboration

Now we will discuss why it's important to do each step. It is important that you know why you should do each step correctly. Pay very close attention and think hard. I'm going to ask you some questions and I want you to raise your hand if you know the answer.

1. Why should you roll or slide out of bed and get into a crawl position?

   A. To say quiet so no one can hear you.

   B. Staying low will keep you near a blanket for cover

   C. Staying low helps you to see and breather better.

   D. Rolling out of bed and crawling is easier than walking.

WAIT FOR RESPONSE: CORRECT RESPONSE = C

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that staying low keeps us close to the floor where there is more air to breathe."

2. Why should you feel the bottom of the door?

   A. Because the bottom of the door is closer to you

   B. To see if the bottom of the door is hot

   C. To see if the door is closed

   D. To see if anyone is outside the door

WAIT FOR RESPONSE: CORRECT RESPONSE = B

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should feel the bottom of the door to see if the bottom of the door is hot".

3. Why should you feel the TOP of the door?

   A. To see if the top of the door is hot

   B. The top of the door is easier to reach

   C. The top of the door feels better than the bottom

   D. The top of the door is solid all the way through

WAIT FOR RESPONSE: CORRECT RESPONSE = A

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should feel the top of the door to see if the top of the door is hot".

4. Why should you use the BACK of you hand when feeling the door?

   A. To keep from making so much noise

   B. To press on the door gently

   C. The back of your hand can feel heat faster

   D. Because you can't see through the door

WAIT FOR RESPONSE: CORRECT RESPONSE = C

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should use the back of your hand because you can feel heat faster that way".

5. Why should you get back into a crawl position?

   A. Staying low helps you to see and breathe better

   B. Staying low will keep you close to a flat surface

   C. Crawling is easier than walking

   D. To stay quiet so no one can hear you

WAIT FOR RESPONSE: CORRECT RESPONSE = A

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should get back into a crawl position because it helps you to see and breathe better".

6. Why should you brace the door and open it only a crack?

   A. To see if anyone is outside

   B. To listen for noises

   C. To keep fire and smoke from rushing in

   D. To yell for help

WAIT FOR RESPONSE: CORRECT RESPONSE = C

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should brace the door and open it only a crack because it keeps fire from pushing the door open and letting fire come in".

7. Why should you feel the air?

   A. To see if anyone is outside the door

   B. To see if you can get up and run

   C. To see if you should go back to bed

   D. To see if the air is hot or cold

WAIT FOR RESPONSE: CORRECT RESPONSE = D

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should feel the air to see if it is hot or cold".

8. Why should you CLOSE the door behind you?

   A. To keep down noise

   B. So you will know where the doorknob is

   C. To keep fire and smoke out of your room

   D. Closing the door can help someone find you faster

WAIT FOR RESPONSE: CORRECT RESPONSE = C

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should close the door behind you to keep the fire and smoke out of your room".

9. Why should you crawl to the stairs and go down BACKWARDS?

   A. To stay quiet so no one can hear you

   B. Because it is easier and safer

   C. Because there is no other way to do it

   D. Just to see if you can crawl backwards

WAIT FOR RESPONSE: CORRECT RESPONSE = B

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should crawl to the stairs and go down backward because it is easier and safer".

10. Why should you crawl to the outside door of your house?

   A. To yell for help

   B. So you will know where the door is

   C. So you can get out of the house

   D. So you can close the door

WAIT FOR RESPONSE: CORRECT RESPONSE = C

HAVE SUBJECTS SAY OUT LOUD --

"Firemen tell us that you should crawl to the outside door to get out of your house".

APPENDIX G:

WRITTEN REHEARSAL ELABORATION

Appendix G. Written Rehearsal Elaboration

Subject's Name: ______________________________

Date: ______________

Directions:

Circle the correct answer:

1. Why should you roll or slide out of bed and get into a crawl position?

    A. To say quiet so no one can hear you.
    B. Staying low will keep you near a blanket for cover
    C. Staying low helps you to see and breather better.
    D. Rolling out of bed and crawling is easier than walking.

2. Why should you feel the bottom of the door?

    A. Because the bottom of the door is closer to you
    B. To see if the bottom of the door is hot
    C. To see if the door is closed
    D. To see if anyone is outside the door

3. Why should you feel the TOP of the door?

    A. To see if the top of the door is hot
    B. The top of the door is easier to reach
    C. The top of the door feels better than the bottom
    D. The top of the door is solid all the way through

4. Why should you use the BACK of you hand when feeling the door?

    A. To keep from making so much noise
    B. To press on the door gently
    C. The back of your hand can feel heat faster
    D. Because you can't see through the door

5. Why should you get back into a crawl position?

    A. Staying low helps you to see and breathe better
    B. Staying low will keep you close to a flat surface
    C. Crawling is easier than walking

D. To stay quiet so no one can hear you

6. Why should you brace the door and open it only a crack?

   A. To see if anyone is outside
   B. To listen for noises
   C. To keep fire and smoke from rushing in
   D. To yell for help

7. Why should you feel the air?

   A. To see if anyone is outside the door
   B. To see if you can get up and run
   C. To see if you should go back to bed
   D. To see if the air is hot or cold

8. Why should you CLOSE the door behind you?

   A. To keep down noise
   B. So you will know where the doorknob is
   C. To keep fire and smoke out of your room
   D. Closing the door can help someone find you faster

9. Why should you crawl to the stairs and go down BACKWARDS?

   A. To stay quiet so no one can hear you
   B. Because it is easier and safer
   C. Because there is no other way to do it
   D. Just to see if you can crawl backwards

10. Why should you crawl to the outside door of your house?

   A. To yell for help
   B. So you will know where the door is
   C. So you can get out of the house
   D. So you can close the door

APPENDIX H:

ANIMATED/STILL GROUP TRAINING SCRIPT

Appendix H. Animated/Still Group Training Script

Session Time Limit: 45 Minutes

1. Orientation

   Trainer states the following:

   "Each of you has been selected to participated in our special fire safety project. We'll be meeting for a few hours to learn more about fire safety. After we finish you will be tested to see how much you have learned. In order for you to learn everything you must pay close attention. Since we will be doing a lot of crawling, you should wear jeans. We have found that other boys and girls like yourself have really enjoyed this project. I think you will too!"

2. Get Each Subject's Name

3. Modeling

   Use the computer to demonstrate steps 1-11 for situation 1 ("Nothing blocking the path"). Note: To start the program (assumes computer is turned on and contains correct diskettes in drives A and B):

   a. Type "START"
   b. Press the RETURN/ENTER key
   c. Type in the subject's first name
   d. Press the RETURN/ENTER key

   Have subject(s) read the introduction out loud.

   Obey screen prompts thereafter.

4. Rehearsal

   Trainer states:

   > "Now I want each of you to practice the steps two times. Read the instructions on the computer screen out loud and do what they say."

APPENDIX I:

PHASE VS. MEAN RAW SCORE: BOC, BSQ, EBSI

Figure 1. Phase vs Mean Raw Score, BOC

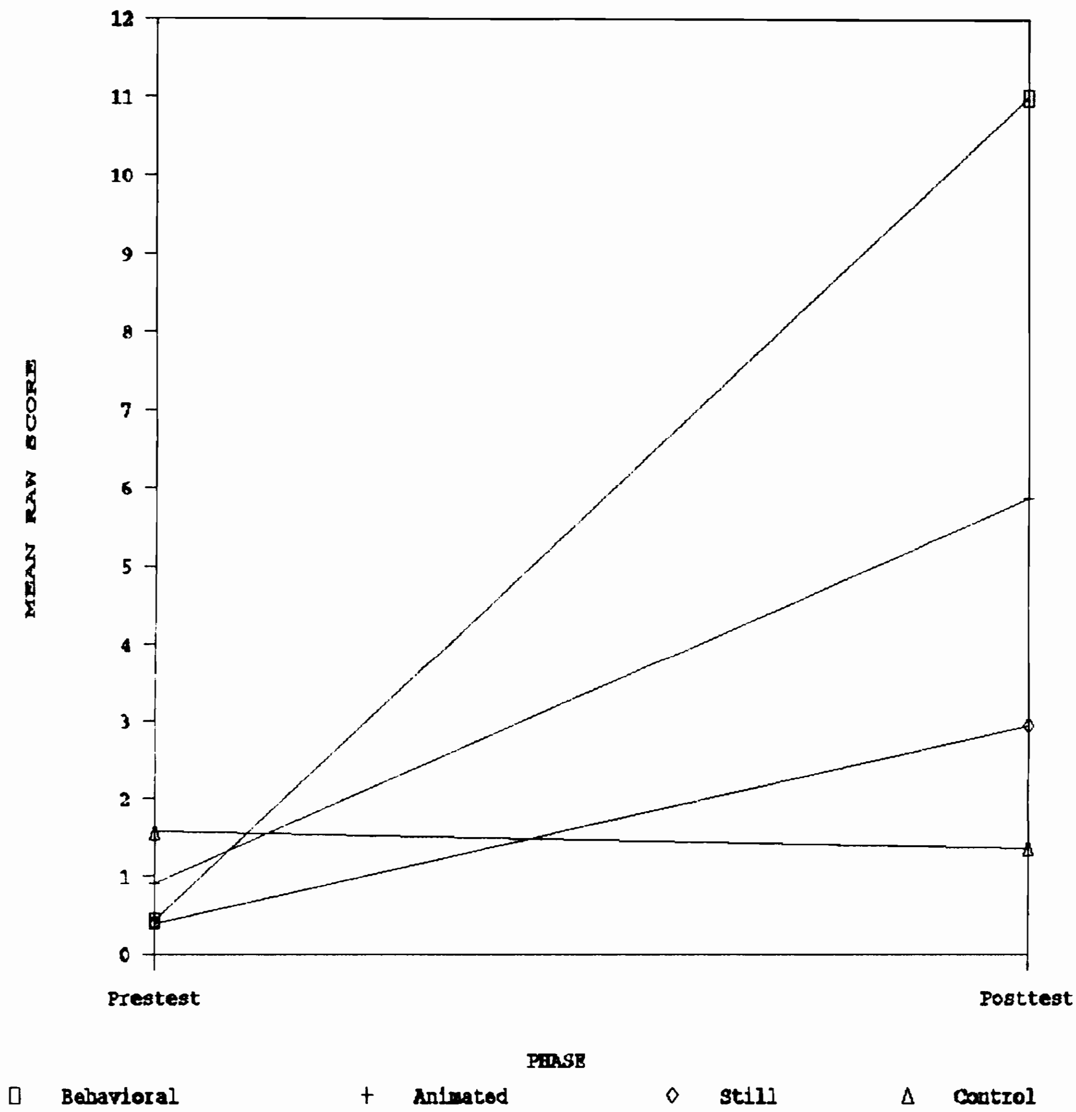


Figure 2. Phase vs Mean Raw Score, BSQ

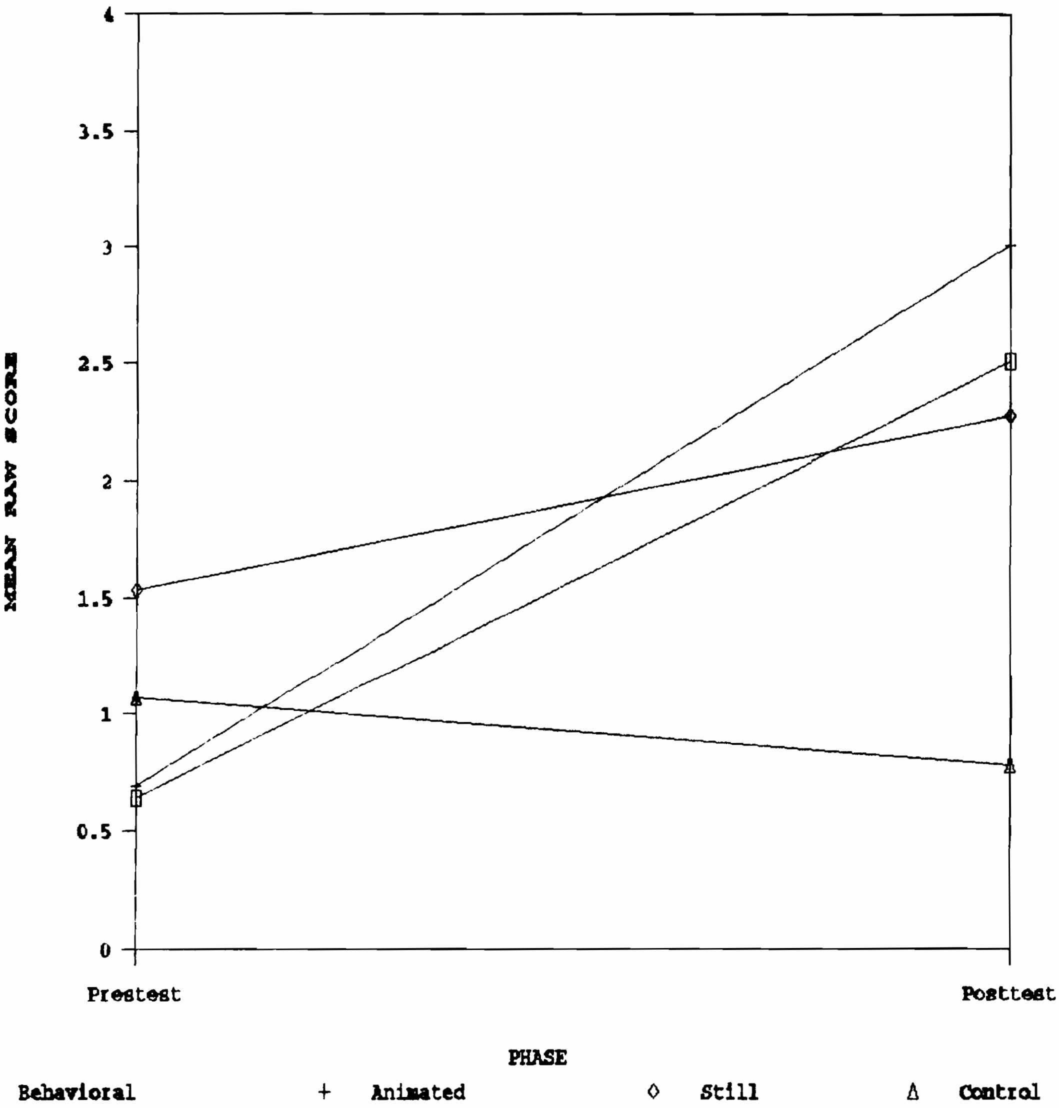
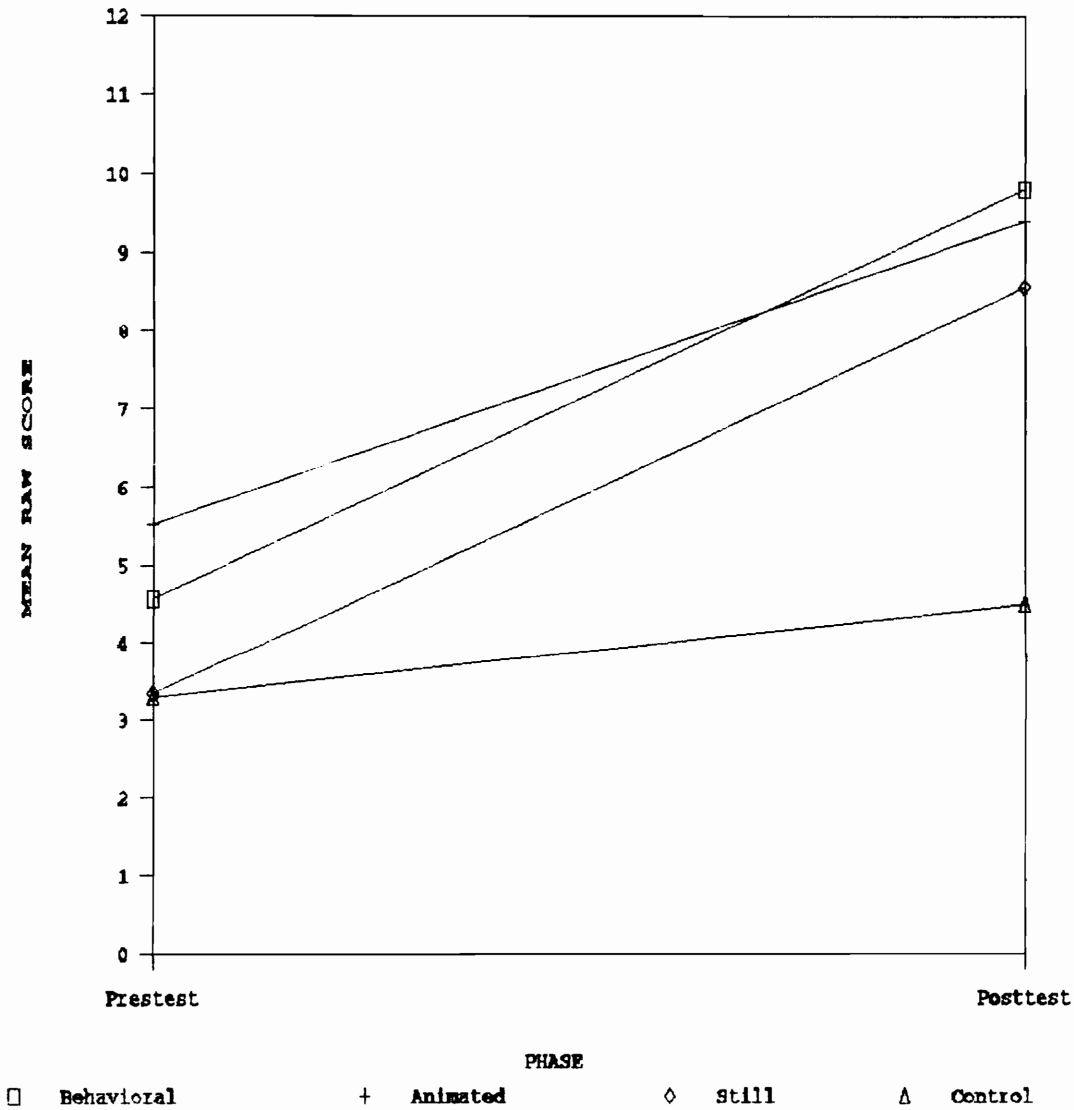


Figure 3. Phase vs Mean Raw Score, EBSI



VITA

Glen Allen Holmes

EDUCATION:

Ed.D.	Curriculum and Instruction, May 1991, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.
M.S.	Science Education, June 1976, Radford University, Radford, Virginia.
B.S.	Biochemisty, June 1973, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

EXPERIENCE:

Automated Process Control Programmer Analyst, Hercules, Inc., Radford, Virginia, 1986-Present.

- Designed, installed, and monitored software programs which control automated chemical production facilities

Industrial Training Representative, Hercules, Inc., Radford, Virginia, 1985-1986.

- Designed, developed and implemented industrial training programs for chemical production facility employees.
- Coordinated group project on interactive-video training

Industrial Production Foreman, Hercules, Inc., Radford, Virginia, 1983-1985.

- Supervised wage employees in Chemical Process group.

Classroom Teacher, Montgomery County Schools, City of Radford, Montgomery Count, VA, and Radford, VA. 1973-1979, 1981-83.

- Secondary level instructor in physics, chemistry, and mathematics.

Graduate Teaching Assistant, Virginia Polytechnic Institute and State University, Blacksburg, VA, 1979, 1979-81.

- Supervised secondary-level student teachers.
- Assistant co-ordinator for NSF Environmental Summer Project.

Visiting Lecturer, Radford University, Radford, VA, Summer 1980.

- Taught undergraduate courses in Physical Science and Photography.

Adjunct Staff Member, New River Community College, Dublin VA. Fall, 1980.

- Coordinated tutorial and remedial courses in physics/physical science.

PROFESSIONAL ORGANIZATIONS:

Phi Delta Kappa Educational Fraternity
American Psychological Association

COMPUTER LANGUAGES/APPLICATION SOFTWARE:

BASIC, Pascal, Fortran, C, SAS, SPSS
dBase, Lotus, WordPerfect

ACADEMIC HONORS:

Phi Kappa Phi Honor Society

PUBLICATIONS:

Holmes, G. A., & Sherman, T. M. (1989). Applying computer spreadsheet technology to front-end instructional design tasks. *Performance and Instruction, 28(3),* 7-11.

PRESENTATIONS:

Holmes, G. A., & Jones, R. T. *The effectiveness of computer assisted instruction methods in coping skills training.* Paper presented at the American Psychological Association Annual Convention, August 1990, Boston, Massachusetts.

Holmes, G. A., & Sherman, T. M. *Using the computer as a decision-making aid in the analysis of instruction.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA, April 1988.