CHAPTER I

The Problem

Significance of the Problem

The availability of computer systems has resulted in an increased use of computers for teaching and learning in education. Computers and peripheral hardware enable educators to incorporate video, sound, and animation into instruction. Authoring software provides another level for computer use by allowing educators to develop and use multimedia instruction and programs designed for specific learning outcomes. New technologies, such as the micro computer as an instructional tool, are providing teachers and learners the opportunity to explore alternative ways to learn (Hansen, 1995). If these new technologies are to become an effective component of the teaching-learning environment, educators and media developers must have access to research-based information that will guide them in selecting and developing appropriate media and instructional applications. Cruickshank (1990) states that "by knowing the research on what constitutes the most effective educational practices, teachers can evaluate their own practices and perhaps modify them" (p. 63).

One dilemma many educators face when integrating technology into the classroom experience involves selecting an appropriate delivery medium. A sampling of the numerous options available include transparencies, color slides, video, audiotapes, and computer-based variations of text, audio, graphics, animation, and video. Emerging technologies such as artificial intelligence, asynchronous computer conferencing, and interactive digital video and optical formats provide yet another level of delivery mediums from which educators can select (Hannum, 1990). Contributing to the ease of use of authoring software is the access to ready-made graphics, sound, and animation (Liedtke, 1993). The availability of media technologies contributes to their use and, in turn, more media is used in educational settings. While in some cases more may be better, it brings to light the issue of appropriateness. Employing the most appropriate media is key to achieving the desired learning outcomes; however, the selection or development of media is often based on the software features of the medium, such as trendy special effects, rather than the effects it has on learning.

Dwyer (1978) indicates that there are multimedia development guidelines available, but the use of a "new technology" such as multimedia systems often precludes the use of research-based instructional theories as part of the decision making or selection process. Croft (1993-94) suggests that using technology without a view towards new applications can result in the technology becoming the purpose rather than the way of achieving objectives. While the use of new technologies may have value, it is plausible that the value in influencing teaching-learning processes could be increased if the technologies are introduced in appropriate teaching-learning settings.

Further complicating the technology integration picture is the research that is available investigating the effects of media on learning.

Conflicting results from research contribute to the confusion educators face when evaluating or selecting an instructional delivery medium. Clark (1983) concludes that

> consistent evidence is found for the generalization that there are no learning benefits to be gained from employing any specific medium to deliver instruction. Research showing performance or time-saving gains from one or another medium are shown to be vulnerable to compelling rival hypothesis concerning the uncontrolled effects of instructional method and novelty (p. 445).

While Clark's analysis of instructional technology research maintains that there are little or no significant gains in learning using any specific media, he does contend that a more productive research alternative to those studies which focus primarily on the media type would be to "...place more emphasis on instructional methods, content, and learners" (1983, p. 34). Studies which focus on the variables proposed by Clark, and specifically the content, tend to deal with the cognitive domain. Since most learning begins in the cognitive domain (Schwaller, 1995), research that focused on this domain would be most likely to yield results that would pertain to a large number of disciplines, educators, and media developers. Unfortunately programs such as technology education which include experiential activities as an integral part of the learning process (Korwin & Jones, 1990) should not rely on cognitive performance alone as the sole indicator of successful completion of the learning objectives. While psychomotor learning should not be considered the sole purpose of technology education, it is a most viable and significant aspect of learning and performance in technology education.

In the Technology Education classroom, hands-on experiential activities add value to the instruction and require some degree of psychomotor performance. Effectively presenting psychomotor content to the learner could increase performance of instructional objectives, thus providing an enriched learning environment. This study is an attempt to investigate the efficacy of multi-sensory instructional methods (i.e. visual, verbal, and visual/verbal) using Computer-Based Instruction (CBI) as the carrier. CBI was chosen because it is a current delivery vehicle widely used in both education and industry and psychomotor content was chosen because it is an integral component of technology education.

Purpose of the Study

This study is designed to investigate the effect of visual only, verbal only, and visual/verbal instructional methods utilizing Computer-Based Instruction (CBI) as the vehicle, on the performance of psychomotor skills and knowledge. The information resulting from the study will guide educators and instructional developers in selecting and designing appropriate instructional methods for psychomotor learning objectives.

Research Question

Do visual-only, verbal-only, or a combination of visual/verbal instructional methods which incorporate the use of Computer-Based Instruction significantly increase performance in the psychomotor domain? The instructional methods that will be used are a video-only, audio-only, and an audio/video presentation of instructions for completing a complex technical performance task.

Assumptions

The following assumptions are made about this study and the circumstances surrounding it.

1. The participants in the study will understand and follow the instructions relative to the psychomotor task and have the physical and mental capacity and ability to complete the task.
2. The treatment groups and the control group will be comparable in regards to spatial and verbal abilities.
3. The participants will be comparable by virtue of university major, class status, and number of courses requiring psychomotor performance.

Limitations of the Study

The limitations for this study concern the study group, the CBI treatment methods, and the psychomotor performance task used for evaluation.

1. The study sample was comprised of college students who are enrolled in Industrial Technology courses at a mid-western comprehensive state-supported university. The sample included a diverse range of majors, but the majors were not representative of a typical university population in that the majority of the participants were in programs of study that require the use of visual aptitudes and praxiological performance. A partial listing of programs of study include Industrial Technology, Technical Illustration, and Technology Education.

2. The CBI treatment modes for each group were developed by the researcher. The content for the CBI was consistent, based on time and substantive content, throughout the three treatments and was based on the procedural instruction for the performance task. A script was developed that contained both verbal and visual information for the instruction and was used to guide the production of the visual/verbal treatment. The video information contained in the script was isolated and used as the guide for producing the visual-only treatment and the verbal information was isolated to serve as the script for the audio-only treatment.

3. The performance task selected for the study involved assembling a manipulated 35mm slide using a Gepe Mount. The Gepe system is used in situations where digital slide generation systems (computer, slide recorder and software) are not available or when a small number of slides are needed with time or cost restraints. The typical process for creating a digital slide involves electronically assembling the slide components (text, graphics, and images) and outputting to a film recorder. The film recorder in the most basic sense is a camera that is

focused on a miniature high resolution monitor contained in a lightproof case. The exposed film from the recorder can then be processed utilizing standard processing procedures for slide film. The Gepe slide resembles a processed slide case in shape but is composed of two color-coded plastic halves which snap together and make it reusable. The Gepe slide also contains glass in both of the image areas. The inside of both halves of the slide contain a thin strip of metal with slots which secure additional components in registration. The function of the Gepe slide is to allow individual components, such as slide masks, color transparencies, and colored gels, to be manually combined to produce a slide.

Definition of Terms

Definitions for technical terminology are often defined according to the discipline or profession in which they are used. For example the term *square* can be used to describe an object, an area, or even a person depending on the situation. In order to ensure consistency throughout the study and for future replication, the following operational definitions are provided.

Computer-Based Instruction (CBI). Instruction that utilizes a computer system to present instruction using aural, visual, or aural-visual elements such as video, audio, text, graphics, and animation.

Visual Communication Technology. The conceptualization, development, production, application, and control of visual media used to communicate information.

Script. Technical directions used as a guide by a media producer that contain narrative, illustrative, and procedural guidelines descriptive of the presentation.

Performance. The act of applying cognitive, affective, and psychomotor knowledge and processes in the completion of a learning task. It is dependent on learning and experience and is exclusive from capacity and ability.

Kodalith Slide Mask. High contrast 35 millimeter film that produces an image area that is either black or open.

Summary

This chapter presented the significance of the problem and the purpose of the study. Also addressed were the need and significance of a study designed to investigate various methods of instruction for psychomotor performance. Chapter Two presents a comprehensive review of literature which focuses on instructional methods, computer-based instruction, psychomotor performance, and technology education.

CHAPTER II

Review Of Literature

Introduction

The review of literature for this study includes information from three primary areas. The first area focuses on computers as instructional tools in the classroom and research related to the application of visual and verbal instructional methods. The second area relates to the domains of learning and specifically focuses on the psychomotor domain. The third area for review deals with technology education and the relationship of psychomotor learning. In addition, information regarding video production, visual communication, and gender differences is provided.

Learning from Media

Traditionally, the focus of media research has involved comparison studies that investigate the comparative efficacy of traditional methods of delivery and new instructional technologies. This approach has received much criticism due to the idea that "...media are generally the 'inert' carriers of instructional messages rather than the 'active ingredient' in learning" (Mielke, 1964, p. 134). Clark (1983a) suggests that the focus for evaluating the efficacy of media on instructional outcomes should not be on the media type but, rather, focus on the instructional methods, content, and the learner. Clark & Sugrue (1989) provided a summary of media research that maintains that learning which does occur from well-constructed media presentations is due to three variables--learning task type, individual learner traits, and instructional method. Therefore it is plausible to suggest that an understanding and application of learning task type, learner traits, and instructional methods must occur before consistent success with instructional media presentations is realized.

Dual Coding

The dual-coding model, developed by Paivio (1971, 1986) proposes that two types of information (verbal and visual) are encoded by separate subsystems (Figure 2.1). One subsystem is specialized for sensory images and the other specialized for verbal language.

> Functionally, the two subsystems are independent, meaning that either can operate without the other or both can operate parallel to each other. Even though independent of one another, these two subsystems are interconnected so that a concept represented as an image in the visual system can also be converted to a verbal label in the other system, or vice versa (p. 222).

Burton & Bruning (1982) conclude that "...an image can be a picture or a sound or even perhaps a taste, while the verbal store, on the other hand, is construed broadly to mean a language store" (p. 33).

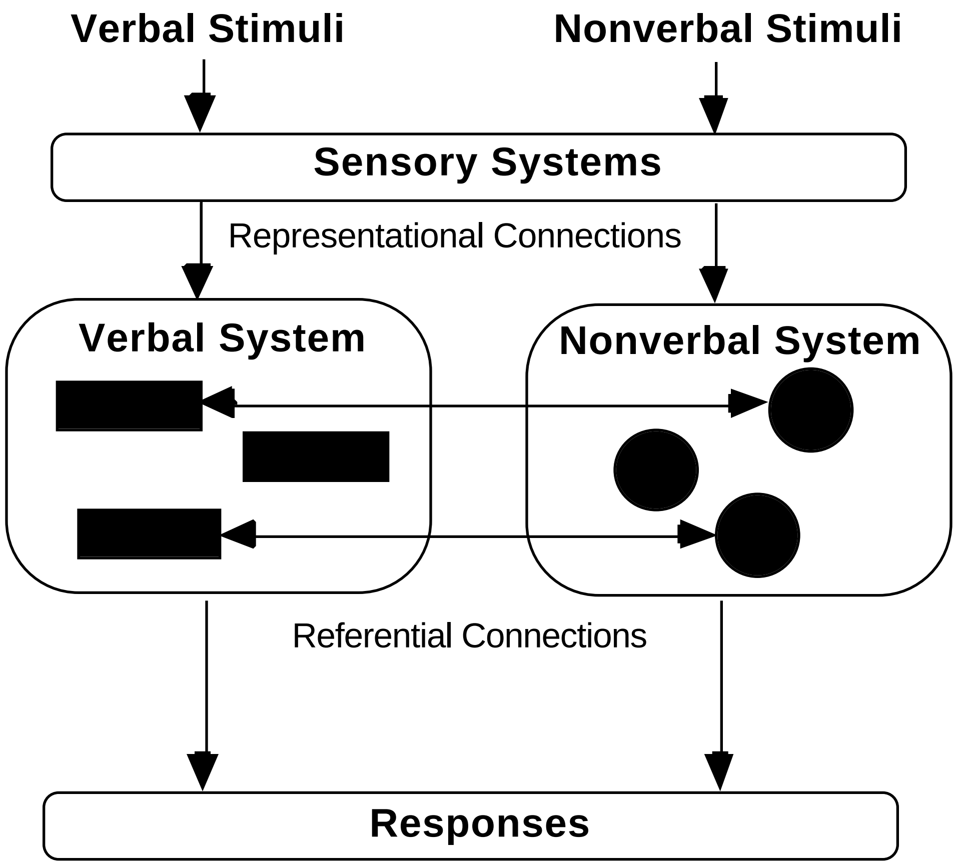

Figure 2.1. Pavio's Dual-Coding Model.

Verbal system units can represent visual words, auditory words, and writing patterns; while the Nonverbal system represents units such as visual objects, environmental sounds, tactile memories, taste memories, and olfactory memories. The two systems are functionally independent yet cognitive activity can occur simultaneously in both systems (Neale, 1994). Childress (1995) explains the interaction by stating:

> When a person sees the word 'table' for example, 'table', through referential processing, triggers visual referents in the visual system, which in turn activates the process of association, resulting in representations of dining tables, picnic tables, card tables etc. Likewise, when a person sees a picture of a table, that picture

> triggers the word table in the verbal system, resulting in representations such as the words dining table, picnic table, and card table. Thus verbal stimuli precipitate visual representations, and visual stimuli set off verbal representations (p. 22).

Single Channel Communication

Single channel communication theory is based in the premise that the human processing system is of limited capacity (Travers, 1968; Miller, 1956). If information arrives simultaneously in separate channels, an overload occurs resulting in a filtering process which allows only essential information to be received (Broadbent, 1958). In a review of single and multiple channel studies, Fleming (1970) concluded that many instructional programs utilizing multiple channels overload the presentation with stimuli that may confound the learner.

In reviewing this information, one may conclude that information presented through more than one channel will impede learning. Research that supports this theory has generally relied on the simultaneous presentation of conflicting or unrelated stimuli, such as nonsense syllables and words, which would require the learner to attend to only one channel (Moore, Burton, & Myers, 1994, & VanMondfrans, 1963).

Multiple-Channel Communication & Cue Summation

Multiple channel communication involves simultaneous presentation of stimuli through different sensory channels (Dwyer, 1978). The ability to accommodate simultaneous (multiple channel) aural and visual stimuli and the amount and type of information that can be processed is important to communication theorists (Moore, Burton, &

Myers, 1995). This information guides media developers and educators when selecting appropriate media for instructional use.

Cue summation theory involves the number of cues across or within a presentation channel and predicts that learning is increased as the number of available cues or stimuli is increased (Severin, 1967). Miller (1957) supports this theory by stating:

> When cues from different modalities (or different cues within the same modality) are used simultaneously, they may either facilitate or interfere with each other. When cues elicit the same responses simultaneously, or different responses in the proper succession they should summate to yield increased effectiveness. When the cues elicit incompatible responses, they should produce conflict and interference (p 78).

Studies that provide plausible support to Severin and Miller generally indicate that the relevance of available cues is an important factor contributing to learning (Bither, 1972, Calvert, Hudson, Watkins, & Wright, 1982, and Pezdek & Stevens, 1984). Hartman (1961) distinguished four relationships between information presented in multiple-channels--redundant, related, unrelated, and contradictory. If messages are contradictory or unrelated, they compete with each other for attention and interference is produced. If the messages are redundant and related, they complement each other to improve learning (Hanson, 1989 and Ketcham & Heath, 1962).

Computer-Based Instruction (CBI)

Since the introductions of the Harvard Mark I, the German Enigma Machine, and the Electronic Numerical Integrator and Calculator (Evans, 1979), computer technology has continually advanced in the development of the personal computer that is now commonplace in work, home, and learning environments. The availability and simplicity of computers and supporting hardware and software as tools, with seemingly unlimited potential, have propagated the increased use of computers in education. CBI systems can provide digitized user-controlled video, graphics, text, sound, and animation to provide learners with a consistent presentation that can be viewed as often as required (Chen, 1994-95). Prepackaged educational programs and multimedia development software have added to the attraction of using CBI in the classroom. The ability of both the educator and the learner to manipulate, control, and display information relating to learning tasks, allows for a more customized presentation of information (Rajkumar & Dawley, 1994).

Computer-based instructional systems have been incorporated into the educational program of many government agencies, businesses, industries, and education (Hannum, 1990). While CBI has merged in the natural progression of technology supporting education, the application and use of such technology requires selection of an appropriate instructional method consistent with the learner and the desired learning objectives. One must consider the value of CBI in the educational experience in that the value of CBI, as a technology supporting education, relies on the ability of the educator to use it in a way that is more effective and efficient than other means of instruction (Croft, 1993-94).

Applications of computers in the classroom can be broadly classified as a 1) classroom presentation system, or 2) computer and tutorial laboratory (Rajkumar & Dawley, 1994). A computer used as part of a presentation system enables the presenter to incorporate a wide variety of information such as graphics, spreadsheet, hypertext, digital video, word processing, and simulation (Pisciotta, 1992). Rajkumar & Dawley (1994) point out that “This approach does not supplant transparencies, or the regular chalk board. Instead, it increases the variety of instructional methods by allowing the computer to be used in addition to the conventional modes of teaching” (p108). Computers used in a laboratory setting is a common occurrence in education. In a computer laboratory setting the purpose should not be to augment a lecture, but to provide hands on training which allows students to use the computer as a tool to manipulate and solve problems relative to the learning task. Also the laboratory setting allows students to perform instructional tasks at their own pace which can result in shortened learning time (Rajkumar & Dawley, 1994).

Visual and Verbal Research

An advantage of CBI is the capability to present information both aurally and visually in response to the sensory capabilities of the learner. While a common practice when utilizing CBI is to respond to as many senses as possible, this approach can be detrimental to the learning process. Although there is support for such an approach, there is also conflicting evidence that suggests learners have the capacity to handle only one source of input at a time. The following is a review of research that supports both approaches to instructional sequencing.

Static Visuals. Current research investigating the use of static visuals or pictures has concluded that their use does help in the processing of text (Reiber, 1990; Siribodhi, 1995). Pictures provide an actual physical description of an object allowing the learner to easily visualize an object while increasing retention (Pea, 1991). Drawings are useful when instant recognition is critical while showing the internal structure of a component or the way the component fits together (Bogert, 1989). Additional evidence suggests that experience plays a role in the effectiveness of visuals on the learner. Young or novice learners tend to derive greater benefits than older or more experienced learners when visuals are used (Reiber, 1990; Levie & Lentz, 1982). More experienced learners have an increased capacity to form mental images based on previous experience (Pressley, 1977). Furthermore, the complexity of visuals can affect learner processing in that learners may ignore complex or overly detailed visuals due to their inability to identify appropriate learning cues (Dwyer, 1978).

Visual and Verbal Information. When using static visuals in conjunction with text, research indicates that visuals that are congruent to the text are most helpful (Willows, 1978). Congruency refers to text that complements or relates to the visual rather than text that is not related to or presents conflicting information about the text. Stone & Glock (1981) investigated the effects of text only, illustrations only, and text with illustrations instructional methods on the performance of second and third-year college students building a toy cart. They concluded that those students who received the text with illustrations treatment experienced fewer errors when completing the performance task. In addition, the illustrations only treatment group experienced fewer errors than the text only group. This suggests that the addition of illustrations or the use of illustrations over text conveys spatial information more effectively than text alone.

Nugent (1982) presented an encyclopedia film to fourth, fifth, and sixth graders with visuals and print; visuals, print, and audio; visuals and audio; visuals alone; print alone; and audio alone treatments. While no significant differences were found between the print, audio, and visual alone conditions, the visuals with audio and the visuals with print produced significantly higher recall of factual information than either the visuals or audio alone. However, the visuals plus audio treatment groups had significantly higher accounts of recall than did the print plus audio. These findings suggest that using a visual/verbal presentation can increase retention over visual alone or verbal alone presentations.

Findings from a Powell & Harris (1990) study reported that different instructional formats did not affect SCUBA-diving performance (Green & Powell, 1988). Additional findings reported by Powell & Harris (1990), consistent with their earlier study, suggest "...that psychomotor task performance is not dependent on how instructions are presented and that sex has no differential effects on the psychomotor task of marble placement" (p. 1187). These results may be attributed to the performance task. The task (marble placement) was relatively simple (moving a marble from one location to another) and may not have provided an adequate level of discrimination. Success or failure by the subjects was not based on the psychomotor performance but on the ability to remember the location for placing the marble. In a study investigating workers' performance, Kammann (1975) found performance increased when operating instructions for a complex phone system were presented in flow chart form rather than paragraph form. These findings suggest that the complexity of the task is linked to the learning benefits of visuals over text.

Video and Animation. The attributes of effective animation for learning are linked to visualization, motion and trajectory (Klein, 1987). A learning task that requires visualization, motion, and trajectory for completion would benefit from animation that contains those qualities (Childless, 1995). Carabello (1985) found no differences between conditions of text only, text with static visuals, and text with animated visuals that explained the physiology of the human heart. It was suggested that the nonsignificant findings were in part due to visuals that did not support the task (Neale, 1994).

Kuzma's (1991) review of media research indicates that most studies examining the effects of video alone, audio alone, and video with audio reported increased recall with the combined video and audio condition. Baggett (1979) presented subjects a story in a video or audio condition and tested recall immediately following by requiring the subjects to write a summary of the story. Findings indicated that there was no significant difference between the video or audio condition immediately following the presentation However, testing one week later indicated that the subjects receiving the video treatment provided a more complete story summary suggesting that when time is a factor between instruction and performance, video is more effective than audio on recall.

Visual and Verbal Sequence. Attempts to determine if the order of presentation of visual and verbal material have yielded inconsistent results (Rieber, 1990). A study by Noonen and Dwyer (1993) concluded that college level learners benefited regardless of the visual or verbal sequence when presented identical content that focused on the physiology and functions of the human heart. The researchers attributed the results to the experiential level of the subjects and their ability to adapt to the varied sequencing. Studies by Childress (1995) and Mayer & Anderson (1991) also concluded that the order of presentation of verbal and visual information did not produce significant differences in recall performance. Childress (1995) concluded that "...the presentation order of the material may not be as important as the content of the presentation in which verbal information is presented" (p. 71).

Learner Control. When developing or using media for instructional tasks one must consider the amount of freedom a learner has in their interaction with the instructional presentation. The design feature of control is addressed in the development of media and can be a learner controlled (nonlinear) or programmed controlled (linear) approach. Nonlinear programming of CBI allows the user the option to make decisions, to exercise control, and to assume some amount of responsibility in interacting with the instruction (Santiago & Okey, 1992). The inverse is a linear approach that requires the learner to progress via one route, through a predetermined structure of content and is referred to as program control (Reeves, 1993).

"An individuals ability to control the path, scope, and pace of instruction is the basis of the learner control strategy" (Wicklein, 1986, p. 15). A proposed benefit of a high level of learner control is that it requires the learner to become actively involved in the instruction due to the learner determining the depth and order in which information is accessed. Additionally students may determine their own pace of instruction taking time to review by engaging in drill and practice or by reinforcing concepts and facts pertaining to the instruction (Farrell, 1991). Allowing students to determine the amount of practice within a CBI program, Fredericks (1976) reported a significant savings in instructional time compared to a program controlled presentation of the same material.

Allowing the students the opportunity to make decisions regarding their interaction with CBI is the major premise of a learner controlled approach in that the learner is more likely to know what information they are missing (Fishbein, Van Leeuwen, & Langmeyer, 1992). "However, the effectiveness of learner control has not been optimized due to difficulties on the part of the learners to make good decisions" (Santiago & Okey, 1992, p. 47). Programmed control of instructional sequencing is a feature that is designed into the instruction that limits the decision making requirement of the learner for determining navigation sequence. The developer structures the program in a linear or sequential manner that requires the learner to progress through predetermined orders of information and evaluation.

While support can be found for either a linear or nonlinear approach to programming, Jacobs (1992) provides the following view of the issue.

> Some empirical research, beginning with a classic experiment by Pask and Scott (Pask, 1972), has shown that learners will choose their own best learning strategies if conditions are well planned in advance. However, a mounting body of evidence suggest that learners generally tend not to choose wisely when confronted with learner-controlled system (Jonassen, 1990). In any case, as Joseph Jaynes has pointed out, most learners 'have little time and less interest in exploration: they want to be led' (Jaynes, 1989)... (p. 120).

From this perspective it would be plausible to suggest that there are other factors that influence the efficacy of a linear or non-linear programming approach on learning. Factors such as those mentioned in regards to media studies including content and task type, and individual learner traits (Clark, 1983; Clark & Sugrue, 1989) and the level of learner control provided.

Learning Domains

Learning theory promotes the concept of learning domains. The idea is that learning that takes place can be associated with a specific domain. In reality it is difficult to separate and categorize a learning task into one domain because learning that does take place is influenced by all domains. For example the use of screen printing to produce a design on a shirt is accomplished pulling a squeegee across a screen and is considered a psychomotor task; however, to perform the task skillfully, one must first understand why pressure from the squeegee affects ink density and make an attempt at producing consistent quality results.

Bloom's Taxonomy is a tripartite organization that suggests that learning occurs in three domains: cognitive (knowledge), affective (attitudes), and psychomotor (skill) (Bloom, Englehart, Furst, Hill & Krathwohl, 1956). Cognitive learning involves the development of intellectual skills and abilities and consists of the following six levels; Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Performance in each level from knowledge to evaluation indicates a higher order of learning has taken place. Objectives from the cognitive domain vary from simple recall of material to creative methods of generating and synthesizing new ideas and materials. The affective domain involves development of attitudes, feelings, values, and emotions and includes the following levels; Receiving, Responding, Valuing, Organization, and Characterization by a Value or Value Complex. Affective objectives range from simple attention to selected phenomena, to complex qualities of character and conscience that are developed over time and through experience. The psychomotor domain is concerned with the development of muscular skills and coordination. Objectives from this domain emphasize motor skill, manipulation of materials or objects or an act which requires neuromuscular coordination (Krathwohl, Bloom, & Masia, 1964). This could be a performance task as simple as using a screwdriver to fasten a picture frame holder or as complex as using a series of tools and instruments to perform brain surgery.

Psychomotor Domain

Various academic fields have contributed to research in the psychomotor domain and include experimental psychology, differential psychology, and industrial psychology. In the experimental psychology field it was Woodworth's book *Le Movement* that started the study of psychomotor skill acquisition in 1903, but it was not until 1943 that the major surge in research began (Holding, 1989; Shemick, 1985). This, in part, was a response to the military's problem of selecting air crews for World War II. Skill research resulted from wartime demands for high-speed and high-precision performance (Holding, 1989). Differential psychology involved interests in the identification, description, and measurement of the ways people differ in abilities, trait, aptitudes, and interests. Industrial psychology grew out of differential and experimental psychology in an attempt to apply scientific research to problems in the workplace. While each of the previous disciplines maintains a different focus regarding the analyzing and application of psychomotor facilities, the common element involves the descriptive structure of the psychomotor domain (Shemick, 1985).

Psychomotor Development. A model (Figure 2.2) depicting the relationship between the reception of stimuli and response is provided by Sage (1972). As internal and external stimuli are received by the sense organs, the relevant information is attended to selectively and the information perceived to be relevant is attended to. Blankenbaker (1985) identified eight factors that correlate with attention and provide focus to relevant information. The eight factors are intensity, novelty, set, motivation, expectancy, experience, ongoing sensory information, and demands of the task. Research investigating attention during psychomotor performance indicates that attention demands decline with practice and that the learners ability to attend to meaningful information facilitates successful performance (Magill, 1989). In addition, the learners' experience effects their ability to attend to relevant information. More experience results in a learner who has the appropriate set or knows what to expect. Experience level can also reduce the effect of novelty in that more of the stimuli will have been previously experienced. The learners' attention to stimuli is effected by their level of arousal or alertness. Blankenbaker (1985) identified background level arousal such as time of day, state of health, and amount of rest received and stimulus specific arousal such as changing stimuli. Research suggests that the learners attention to stimuli can be improved when the information is presented in the learners preferred mode of perception and when the mode of presentation relates to the type of task (Blankenbaker, 1985).

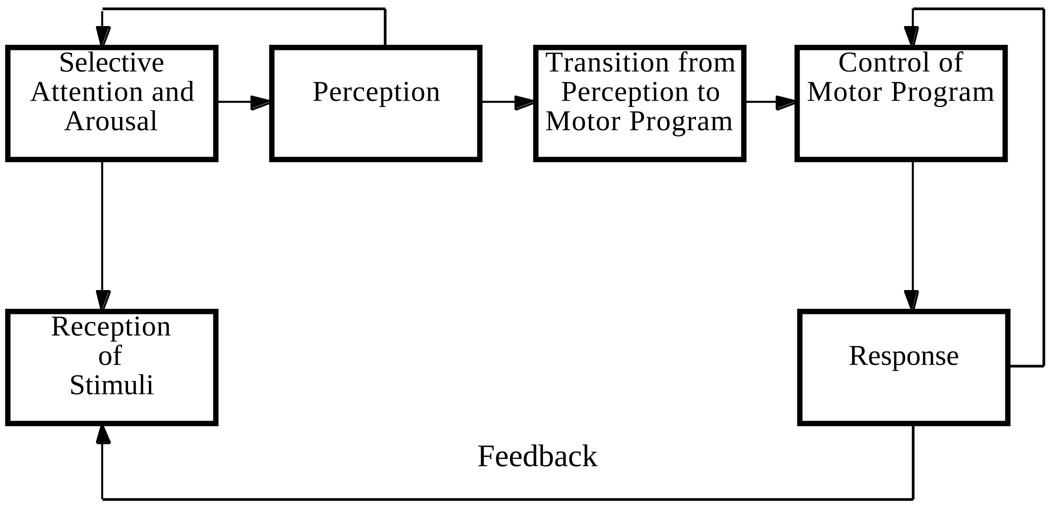

Figure 2.2. Model of Functional and Neural Mechanisms for Motor Behaviors.

Based upon research with young adults performing specialized military tasks, such as flying, Fleishman (1972) identified eleven perceptual-motor factors (Table 2.1) and nine physical proficiency factors (Table 2.2), that consistently occur as factors in psychomotor tasks (Shemick, 1985).

Table 2.1. Eleven Perceptual-Motor Factors (Fleishman, 1972).

1. Multilimb coordination:	ability to coordinate the simultaneous movement of limbs to operate controls.
2. Control precision:	precise adjustments of large muscles groups when operating controls.
3. Response orientation:	ability to rapidly select and correctly move controls.
4. Reaction time:	speed with which a person is able to respond.
5. Speed of arm movement:	ability to move the arm quickly without concern for accuracy of the movement.
6. Rate control:	ability to respond to changes in speed and direction of a continuously moving object.
7. Manual dexterity:	ability to manipulate fairly large objects with the arm-hand movements under conditions which require speed.
8. Finger dexterity:	ability to use the fingers to manipulate small objects.
9. Arm-hand steadiness:	ability to precisely position the arm-hand in movements where speed and strength are minimized.
10. Wrist, finger speed:	ability to move the wrist and fingers rapidly.
11. Aiming:	ability to rapidly mark a dot within each of a series of small circles.

Table 2.2. Nine Physical Proficiencies (Fleishman, 1972).

1. Static strength:	maximum force an individual can exert.
2. Dynamic strength:	ability to exert force repeatedly or continuously over time.
3. Explosive strength:	ability to apply force instantly
4. Trunk strength:	dynamic strength of trunk muscles.
5. Extent flexibility:	ability to flex or stretch trunk and back muscles.
6. Dynamic flexibility:	ability to make repeated, rapid, flexing trunk movements.
7. Gross body coordination:	ability to coordinate action of several parts of the body while the body is in motion.
8. Gross body equilibrium:	ability to maintain balance without visual cues.
9. Stamina:.	capacity to sustain maximum effort which requires cardiovascular exertion

Psychomotor Skill Classification. Attempts to classify skills have lead to a number of proposed models. Generally, the models are results of a need by a particular discipline to classify skills as they relate to the area of study.

The Fitts-Posner model (1967) describes learning as occurring in three phases. The three phases are 1) early or cognitive, 2) intermediate or associative, and 3) final or autonomous. In the cognitive phase the learner attends to knowledge about the task such as understanding directions and attaching verbal labels to movement responses. In this phase, the learner would be processing information relating to task process. For example, if the performance task were lathe turning, the learner would focus on knowledge related to the cutting tools such as which tool is used to produce a specific time in the process. In the associative phase, the learner is primarily concerned with practice conditions and requirements such as frequency of training. For example, a lathe operator in training would focus on performing movements connected with the correct application of different cutting tools with little attention paid to the quality of the product. The final or autonomous stage of skill acquisition is achieved when the learner has mastered the skill and is capable of performance with minimal conscious involvement. The process moves the learner from a highly attentive phase, where emphasis is placed on understanding and performance is crude, to a practice phase and finally to the autonomous phase (Singer, 1985).

The Gentile model (1972) is an attempt to apply skill acquisition directly to teaching (Singer, 1985). Gentile (1972) identified two stages of skill development, namely: 1) general ideas of the act and 2) fixation and diversification, which differentiates between open and closed skills. Stage one involves accomplishing a goal with a general movement pattern, similar to the early and intermediate phases outlined in the Fitts-Posner (1967) model. Stage two is associated with a level of performance and can be related to the final phase of the Fitts-Posner (1967) model. A closed skill is one in which the requirements for movement are consistent, such as the movement needed to turn on a computer. An open skill, such as cutting a compound curve with a band saw, is one that requires a diversification of movement patterns to be mastered because stimuli are unpredictable (Singer, 1985). Examples of movement patterns for cutting with a band saw would include identifying the relationship between blade width and turning radius while making adjustments when cutting, maintaining a stable stance throughout the process, and using aural and tactile senses to maintain an appropriate feed rate of the stock.

Environmental Influence. The environment plays an important role in the effectiveness of the teaching-learning process. Performance deterioration can result if stress is caused from conditions within the environment. "...an environmental stressor may be any condition or aspect of a physical environment which in some way impairs human sensory, cognitive, or motor functions or somehow poses a threat to personal health and safety." (Vercruyssen ,1984; Vercruyssen & Noble, 1984). Examples of environmental factors that can influence performance include natural factors such as temperature, humidity, sunlight and air composition, while artificial factors include mechanical noise, vibrations, motion, etc. and ambient gases. While the numerous effects of combined natural and artificial factors precludes discussion of all of the possible interactions PaDelford (1985) provides focus by stating that “most of the debilitating environmental factors would have an effect on perception, with inadequate lighting and noise being the most obvious” (p 220).

Sound is described by frequency, pitch, amplitude, loudness, and timbre (Alten, 1990). Noise can be arbitrarily defined as any sound that is unwanted, uncomfortable, distracting, intrusive, annoying, irritating, nonsymbolic in nature, or physically injuring. Because of differing perceptions, what may be noise to one person may be pleasing to another and is dependent upon the listener (Herbert, 1976; Vercruyssen & Noble, 1985).

Research suggests that there are levels of artificial illumination that optimize task performance. The illumination levels are based on task conditions and range from 10 to 1,000 foot candles. Tasks conditions range from “general lighting in the home” to “most difficult inspection” with illumination levels increasing for more demanding tasks (Bailey, 1982).

Psychomotor Taxonomy Schemes. The need for a classification structure for the psychomotor domain is addressed by Kelso (1982) who maintains that there are four reasons for such order.

> First, they provide a means of bringing order to the very diverse field of motor skills....Second, the actual process of identifying these common elements may further our understanding of motor skills....Third, these systems help focus research efforts on those elements....Fourth, categorizing motor skills makes it possible to investigate how sample skills from within a category respond to a particular teaching technique (p. 9).

One attempt at bringing order to psychomotor performance is provided by Elizabeth Simpson and is referred to as the Simpson Schema (Table 2.3). The taxonomy was based on the need “...to develop a classification system for educational objectives, psychomotor domain, and if possible, in taxonomic form,...” (Simpson, 1966, p. 1). The taxonomy “...was based on the action pattern concept. That is to say, the levels in the classification schema follow the way a learner acquires a skill” (Shemick, 1985, p. 21).

Table 2.3. Simpson's Schema.

1.0 Perception--parallel to receiving in the affective domain 1.10 Sensory 1.11 Auditory--hearing 1.12 Visual--seeing 1.13 Tactile--touching 1.14 Taste--tasting 1.15 Smell--detecting odors 1.16 Kinesthetic--a sense of feeling or of one's body in space 1.20 Cue Selection--differentiating proper cue as a guide 1.30 Translation--determining the meaning of a cue for action
2.0 Set--readiness for action 2.1 Mental Set--knowledge necessary to enable action 2.2 Physical Set--focusing of attention and body position 2.3 Emotional Set--favorable attitude
3.0 Guided Response--overt act under supervision 3.1 Imitation--copying an observed performance of another 3.2 Trial and Error--multiple response learning--selecting the response which provides the desired results
4.0 Mechanism--learner achieves some confidence and proficiency in the performance of the skill or act
5.0 Complex Overt Response--learner performs smoothly and efficiently 5.1 Resolution of Uncertainty--learner proceeds with confidence
6.0 Adaptation--learner alters acquired skill to meet new situational demands
7.0 Origination--creating new psychomotor acts or ways of manipulating materials out of understandings, abilities, and skills developed earlier.

Other classification schemes for the psychomotor domain include those by Harrow (1972) which classified movement behaviors into six major levels and Shemick (1977) who offered a three level taxonomy which classified skills as being either cognitive-motor, verbal-motor, or sensory-dependent (Long & Moore, 1985). With the numerous classification systems for the psychomotor domain the difficulty lies in selecting an appropriate classification scheme. Shemick (1985) proposes that "...educators will find the educational objectives classification systems of Simpson and Baldwin of greater practical application than the proposals by Cratty and Harrow" (p. 27). It is important to note that the work of Cratty was the result of an attempt to classify skills typical of physical education and that Harrow's work focused on child growth and development. This may have influenced Shemick's (1985) question of appropriateness of those two classification schemes for technology education.

Psychomotor Learning and Technology Education

The precursors of contemporary technology programs include manual training, manual arts, industrial arts, and industrial technology. While the programs were each based on varied historical, philosophical, cultural, and social rationales, one common denominator that has held constant is hands-on experimental activities (Korwin & Jones, 1990). The use of experiential activities adds value to technology education, but the quality of that value could be increased if effective instructional methods for delivering content that falls within the psychomotor domain are utilized.

The three domains identified by Bloom are important to the technology educator in that technology education encompasses total domain learning (Clark, S. C. 1989). PaDelford (1985) maintains that "the acquisition of psychomotor skills involves the perceptual, affective, cognitive, and psychomotor domains as well as creativity" (p 220). Schwaller (1995) provides support to this premise in that while most, but not all, content learned in the technology classroom begins in the cognitive domain, there is a relationship between the domains that suggests that learning that has taken place in one domain will enhance learning in the other domains (Figure 2.3). Consistent with the technology approach, Kemp (1988) maintains that the psychomotor domain be used as a means for students achieving or enhancing cognitive or affective domain goals.

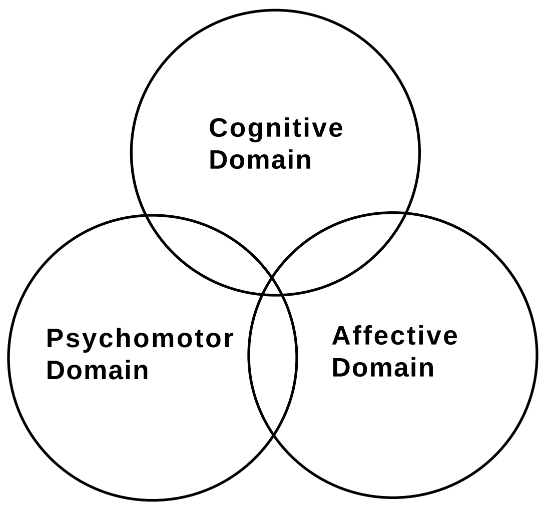

Figure 2.3. Interrelation of Learning Domains.

Skill Acquisition. Early attempts at defining skill were related to performance that applied to workers in American industry (Adams, 1987). Pear (1927) provided a definition in response to that need and is as follows "The concept of skill which is proposed is that of integration of well-adjusted performances, rather than a tying together of mere habits. In man, at least, skill is acquired and fused with natural aptitude" (pp. 480-481). Pear (1948) later revised his definition of skill maintaining that "Skill is the integration of well-adjusted muscular performances" (p. 92). From a comprehensive review of research relating to skills, Adams (1987) identified three defining characteristics of skill.

> 1. Skill is a wide behavioral domain. From the beginning, skill has meant a wide variety of behaviors to analysis's, and the behaviors have almost always been complex.
> 2. Skill is learned.
> 3. Goal attainment is importantly dependent on motor behavior. Any behavior that has been called skilled involves combinations of cognitive, perceptual, and motor processes with different weights (Adams, 1987, p. 42).

Although learning domains exist that categorize learning types as affective, cognitive, and psychomotor, it is evident that they are not mutually exclusive (PaDelford, 1985). For example, in order to be consistently successful, a student developing a black & white photograph must know that the temperature of the developing chemistry determines the developing time; must have a preconceived idea of the desired aesthetic quality of the finished print; and must physically agitate the developing solution to ensure consistent film processing. Performance ability of such a task is related to three variables: 1) consistency of information processing demands, 2) task complexity, and 3) degree of practice (Ackerman, 1990).

The acquisition of a skill carries the learner through three phases identified as declarative knowledge and general intelligence, knowledge compilation and perceptual speed, and procedural knowledge and psychomotor abilities (Ackerman, 1990).

Declarative knowledge and general intelligence	general and broad content abilities are associated with initial task performance
Knowledge compilation and perceptual speed	perceptual speed abilities are associated with an intermediate stage of skill acquisition
Procedural knowledge and psychomotor abilities	psychomotor abilities are associated with asymptotic, automatized skilled performance

Figure 2.4. Three Phases of Skill Acquisition (Ackerman, 1990).

Instructional Strategies for Psychomotor Skill. DeCaro (1985) presented three factors that educators must address in order to effectively select an instructional strategy for teaching a psychomotor task.

> Prior to designing instruction for psychomotor skills, a teacher should: analyze the skill and design the sequence of instruction for the skill. determine whether the demonstration or discovery approach is more valid, and select a means to motivate the student to learn the skill (pp. 154-154).

Analyzing the performance task and designing the sequence of instruction for the skill prior to designing the instruction ensures that the instructional method is the most appropriate for the task. DeCaro (1985) provides the following procedure:

> 1) Define in behavioral terms, the psychomotor skill which is to be the terminal (final) task in the hierarchy.
>
> 2) Derive the hierarchy by asking Gagne's question ("What must the learner be able to do in order to learn this new element, given only directions?") for each element in turn, from the terminal element downward. Include all skills that seem reasonable since the validation process can only disprove postulated connections, not create them.
>
> 3) Check the reasonableness of the postulated hierarchy with experienced teachers and subject matter experts. This can be accomplished by doing one or more of the following: (a) having them critique the posited hierarchy, (b) giving them the elements and having them draw the connection, and (c) having them perform the terminal task and observing them (pp. 157-158).

Before choosing an instructional strategy that is expository in nature (demonstration) or inductive in nature (discovery), DeCaro (1985) identified three variables that should be considered. The difficulty of the task, whether transfer of skill is a desired outcome, and whether or not the nature of the skill is open or closed loop. Research tends to support the idea that demonstration is more effective than discovery for teaching complex skills (Blake, 1980; Singer & Pease, 1976). The complexity of a task is related to experience of the learner in that a task classified as complex for an inexperienced learner may not be complex for a more experienced learner.

The importance of identifying transfer as a desirable outcome or not relates to the application specificity of the skill. If the learner will be required to perform the skill in a consistent environment, then the demonstration method is more appropriate. If the learner will be expected to perform the skill under differing circumstances, then the discovery method is preferred (DeCaro, 1985). For example, a production worker responsible for assembling a circuit board for a computer would benefit from demonstrations that mirrored the expected performance. Whereas a worker who is responsible for troubleshooting defective circuit boards would benefit from a discovery approach which provided strategies for analysis and evaluation of the circuit and its components.

Determining if the nature of the skill to be learned is closed loop or open looped will guide the educator in selecting appropriate demonstration or discovery instructional strategies. Adams (1971) provides the following description of open- and closed-loop skills. Open-loop skills require rapid application and have no feedback until the task is terminated. The skill requires behavior that adapts to continually changing stimuli. An example of an open-loop skill would be a batter hitting a pitched baseball which requires attention to placement of the pitch in the strike zone and the rotation of the ball. A closed-loop skill has feedback, error detection, and error correction elements and the requirements are generally predictable. An example of a closed-loop skill is lathe turning (DeCaro, 1985).

Providing motivation for students to learn is a critical component of the teaching-learning process. The trend from extrinsic motivation such as discipline and grading, toward a more intrinsic approach requires the educator to be more sensitive to the learners' needs (Schwaller, 1995). Students' needs can be divided into sustenance, influence, and self-extension. Sustenance needs include food, sleep, rest, comfort, and group approval, and are essential to a person's well-being. Influence needs are those related to status, significance, position, expertise, worth, and competence. The student typically has more control of influence needs, such as status, than sustenance needs, such as food. The third type of need is self-extension and refers to students having the opportunity to be creative, internalizing, reflecting on ideas, and being able to self-actualize (Schwaller, 1995).

Gender Differences. Early research dealing with gender differences has identified the following well documented variances between males and females (Glickman, 1976):

1. Females have greater verbal ability than males.
2. Males are superior to females in visual-spatial ability.
3. Males excel in mathematical ability.
4. Males are more aggressive than females.

While there are documented differences in regard to gender, some research suggests that the differences can be attributed to experience and expectations of other people. Parents tend to behave differently toward a male baby as compared to a female baby. Examples of behavior differences from parents include the tendency to talk to and look at females more than males and encouraging males to explore and females to remain close (Chance, 1988). Rubin, Provensano, & Luria (1974) asked parents to rate newborns on characteristics such as softness and size and found that parents tended to rate females as being softer than males and males as being larger than females while objective measures showed no differences. Harris (1975) suggests that expectations play another role in gender differences in that society encourages males more than females to engage in activities that require spatial skills such as exploration and manipulation of objects.

Opposing views based on more recent research findings contend that gender differences in regards to spatial ability are less significant than earlier reported. In addition, the research showed no general differences in verbal ability or mathematical ability. However, it was noted that there was no agreement regarding the studies distinguishing between innate and developed capacity. It is noted that training and environmental factors can enhance or limit the performance of instructional tasks thus suggesting that training can improve innate capacity and provide for developing nonexistent capacity (Sapiro, 1994). Evidence that may support this premise is provided by a study conducted by Hammer, Hoffer, & King (1995) that found a relationship between academic major and performance on the Piaget Water-Level Task. The study examined performance of 27 male and 27 female architecture students, and 27 male and 27 female liberal arts students on the water-level task. No performance differences were found between male and female architectural students, but male liberal arts students scored significantly higher that female liberal arts students. It was suggested that either the architecture program greatly improves the spatial abilities of females or that females with superior spatial abilities are selected into the program or consciously choose to enter architecture program (Hammer, Hoffer, & King, 1995).

College enrollment rates of male and female high school graduates (Figure 2.4) indicate that the disproportion in enrollment between gender is becoming more balanced (Alsalam, 1990). Equalization of the gender make-up of the student body coupled with an understanding of gender differences, supports the need to develop instruction that complements both gender preferences.

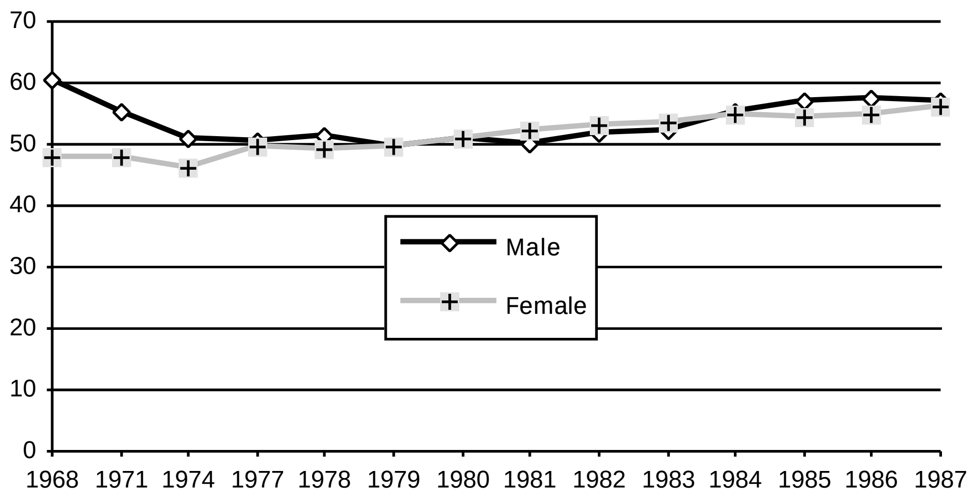

Figure 2.5. Percentage of high school graduates enrolling in college in October following graduation: 1968-1987 (3 year averages).

Utilizing instructional methods that accommodate individual learner traits as a means of facilitating learning as an idea is becoming increasingly more evident in education and industry. Albright & Post (1993) proposed that business and industry is moving from formal employee education toward instruction designed to accommodate human differences, such as learning styles and gender, of their employees.

Implications for responsible educators include identifying the domains of learning that specific content applies to and then customizing the presentation of the materials in an appropriate manner to enhance learning. Several factors influence psychomotor instruction in education and include time, cost, and safety. The time required to repeatedly demonstrate a task may not be available. For example, in a classroom setting, demonstrations are typically performed one time for a group of students instead of consuming more time to present individual demonstrations. Cost is an inhibiting factor in that the typical laboratory budget is a fixed amount and the generation of waste material from repeated demonstration attempts is not desirable. Another concern involves potential hazards associated with the application of a psychomotor skill (Whetstone, 1995). Correct performance in a hazardous environment or the potential hazard of incorrect performance necessitate instructional methods that are effective. Complicating the safety issue further, Kunsman, Manno, Przekop & Manno (1991). suggest that the inability to perform correctly may have economic as well as legal implications. In summary, the rapid and accurate acquisition of motor skills and competencies related to technology education objectives saves time, money, and reduces safety concerns while enhancing total domain learning.

Psychomotor Evaluation. When attempting to evaluate motor skills, one must consider two variables that determine the type of assessment that will take place. An investigator can observe a skill either directly or indirectly while examining the process or the product. This provides four options from which to choose (Figure 2.6) for assessment of motor skills (Erickson, 1985).

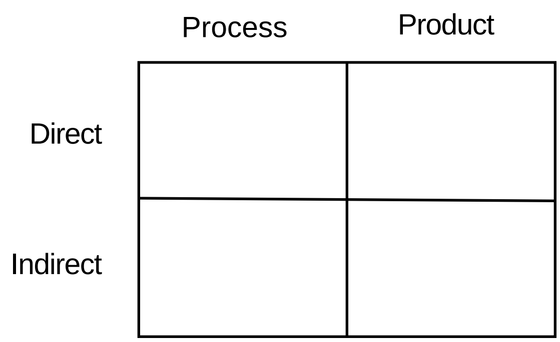

Figure 2.6. Assessment Matrix for Psychomotor Learning

Using video editing of a 60 second commercial as the performance task, examples of the four types of psychomotor evaluation are as follows. Direct process involves visually observing the student performing the video edits as they complete the commercial. Direct product would be based on the evaluation resulting from a visual inspection of the finished commercial compared with predetermined objectives such as requiring a specific number of fades. Indirect process evaluation would be based on the results of an examination testing knowledge or understanding of video editing. Indirect product evaluation would result when the student would be required to develop an edit list for the commercial from field footage.

Direct Product Assessment. Although the procedures and techniques used to directly assess student attainment of performance objectives can vary, Erickson and Wentling (1976) indicate that the direct approach is the ideal method to use. While evaluation of the product rather than the process may appear to ignore procedures, the assumption is made that "...,if the students can produce acceptable end products, then they probably have attained the skills needed to perform as indicated in the performance objective. Usually, quite accurate assessments are obtained." (Erickson, 1985, p. 139).

Situations that may require the application of potentially dangerous processes or tools, such as the use of a laser, may require, for safety reasons, a focus on process rather than product. Direct product evaluation also includes a destructive or nondestructive testing variable (Erickson, 1985). Examples of nondestructive testing procedures include a rating scale based on objective criteria, x-raying a weld, and energizing an electrical circuit. Destructive techniques include a welding bend, adding weight to a model bridge, and a tensile test that are applied until product failure.

Visual Communication

The human need to communicate thoughts and ideas visually has existed since the beginning of civilization (Watts, 1990). While evidence of visual communication can be traced to primitive cultures it was not until 1450 AD that a major technological advance in the printing reproduction process was made.   Before the introduction of movable type by Johann Gutenburg, printed material was not made available to the average person (Karsnitz, 1984). Duvall, Maughan, & Berger (1981) state that while Johann Gutenberg is the person given credit for the developing the printing system, he noted that the necessary components were available already and that Gutenberg was responsible for pulling them together to form a total printing system. This networking of separate technological systems continues to be prevalent in industry today. Digital computers coupled with laser printers, scanners, printing presses, and an endless list of other technologies, produce systems suited to a multitude of processes. Also, there is a networking of various professions, that directly or indirectly supports the industry, to meet the demand of visual communication. One area of visual communication that is relevant to this study is video production.

Video Production

With the availability and decreased cost of video production components, it is apparent why the use of video has become popular in education (Hausman, 1991). In addition, video is a very portable medium in the sense that the information can be presented to groups as well as viewed by individuals in the setting of their choice.

Technically the production of a video involves the coordination of many procedures, each of which have a profound impact on the outcome of the final product. In addition to the technical process, materials such as equipment, props, and people must be located, secured, and organized. The video image is electronically recorded on a thin material coated with a layer of oxide that can be magnetized and is referred to as videotape (Cheshire, 1990). Videotape is available in different formats which include 8 millimeter, 1/2", 3/4", 1", and 2" tape width. Each of the formats has a purpose that best suits the format.

Video systems can be categorized as amateur or professional (broadcast quality) systems. However, the introduction of new technology, such as the Super VHS (S-VHS) and Hi8 format, has narrowed the margin between amateur and broadcast quality formats. Even though there are technical advances that make it difficult to separate the two categories, there are still differences that necessitate the distinction. Broadcast quality refers to the technical specifications of the video signal and the look of that signal (Browne, 1989). This distinction is important because it is possible to achieve a technically perfect video signal with a format such as VHS, yet still not be able to produce a broadcast quality picture. S-VHS format videotape is one recently developed technology that is for the most part considered amateur video yet produces a higher quality picture than conventional VHS. The increased resolution of S-VHS also makes it a better first-generation acquisition format than 3/4" format tape (Heiss, 1988). Technical developments in the S-VHS VCR provides images that are suitable for many broadcast and professional applications (Hirota & Neubert, 1990).

Lighting. A key element of video production is lighting. The type of lights and the lighting techniques used will determine if the image quality appears natural to the viewer (Winston & Keydal, 1986). Different sources (wavelengths) of light produce a different overall cast or color of the image being recorded. Humans are able to constantly compensate for these differences in chrominance; maintaining an image of the picture that satisfies the brain. Adjustments are made for the variance in chroma before the shot by selecting the proper light source, techniques, and maintaining a white balance due to the fact that video cameras are unable to make the compensation for changing light sources. (Winston & Keydal, 1986).

The lighting technique that achieves the most natural look using artificial lights is three point lighting (Winston & Keydal, 1986). Three point lighting consists of a key light, a fill light, and a back light. The key light is the main and most powerful of the three sources. The light is generally a spot and is placed on the or around the subjects eye line. This light strongly illuminates the subject. The second light is referred to as the fill light. The fill light is positioned on the other side of the subject to soften the effects of the key light. The third source of lighting is the back light. The back light is placed behind to separate the subject from the background (Staff Writer, Video Systems, 1986).

Summary

Childress (1995), suggested further investigation of the types (domains) of information which are best presented with the use of animation and narration. A more specific line of questioning on this theme prompted the researcher to develop this study to investigate the efficacy of presentation of psychomotor content using visual only, verbal only, and visual/verbal instructional methods. Because most learning begins in the cognitive domain (Schwaller, 1995), research that focused on this domain would be most likely to yield results that would pertain to a large number of disciplines, educators, and media developers. Unfortunately programs such as technology education which include experiential activities as an integral part of the learning process (Korwin & Jones, 1990) should not rely on cognitive performance alone as the sole indicator of successful completion of the learning objectives. Brauchle (1985) states, "if teachers can present information in such a way that it complements the ongoing mechanism of translating information to action, they can become much more efficient managers of learning" (p. 77). While psychomotor learning should not be considered the sole purpose of technology education it is a most viable and significant aspect of learning and performance in technology education.

According to Calder (1964) a live demonstration is more effective than a television presentation of the same material. Carl (1975) reported that a live class presentation is more effective than a video tape presentation for teaching a selected psychomotor skill. However, technologically, society is more advanced than 25 years ago. According to Bell (1989), innovations such as the change of all mechanical, electrical, and electromechanical systems to electronic systems; miniaturization; digitization; and software, underlie what he calls the third technological revolution. Current advanced technologies provide educators with a unique opportunity to develop more effective instruction in response to the increasing dynamic needs of the learners. In addition to improvements in technology, students today are much more accustomed to interacting with computer generated mediums and learning from electronic and digital formats such as television and CBI.

People within occupations, such as teaching and industrial training, experience the transition from blackboards to overhead projectors to computers and are interested and intrigued by the variety and potential of instructional technologies. The general public, including elementary, secondary, and college level students, view technology, such as the computer, as being the norm and expect such innovations to be a part of the educational process (Levinson, 1988).

The availability and use of innovative instructional tools such as the computer, and the hands-on nature of technology education, support the need for research investigating instructional methods for teaching psychomotor skills. In addition, the dynamic capabilities of technology allow for the presentation of instructional tasks in a variety of formats and with a variety of instructional strategies. Therefore, the following research hypothesis was generated to further explore the efficacy of instructional methods utilizing computer assisted technologies to teach psychomotor knowledge and skills. Based upon on the review of literature, it appears that the use of combined visual/verbal information will increase retention rates and reduce time to learn over verbal only and visual only instructional methods. In addition, gender may influence the performance of psychomotor tasks based on varied instructional methods included as part of the instructional delivery .

Hypotheses

1. The level of performance of the subjects receiving the visual/verbal combined treatment will be greater than the subjects receiving the visual only or verbal only treatments.

2. The level of performance for males receiving the visual only treatment will be greater than the males receiving the verbal only treatment.

3. The level of performance for females receiving the verbal only treatment will be greater than the females receiving the visual only treatment.

4. The level of performance for males receiving the visual only treatment will be greater than the females receiving the visual only treatment.

5. The level of performance for females receiving the verbal only treatment will be greater than the males receiving the verbal only treatment.

CHAPTER III

Methodology

Statement of the Purpose

The purpose of this study is to compare the effects of three instructional methods, which incorporate Computer-Based Instruction (CBI), on the psychomotor performance of college students.

Research Questions

The research questions relate to the performance of psychomotor skills and the appropriate use of visual/verbal information for instruction of psychomotor tasks. Specifically, does visual only, verbal only, or a combination of visual/verbal instructional methods of CBI increase performance in the psychomotor domain? In addition, will gender influence performance between the instructional methods?

Population and Sample

Participants for this study consisted of college students enrolled in courses offered within the Industrial Technology department of Bemidji State University. This institution and these students were chosen due to the psychomotor performance requirements of the programs of study, gender distribution represented by the subjects, availability of a large sample in one location, and convenience of conducting the study during the students' scheduled technology laboratory work time.

The data collection portion of this research was conducted in the Industrial Technology department of the Bemidji State University, in Bemidji Minnesota. Collections dates for the first phase occurred between January 27 and February 5, 1997. Data collection for the second phase occurred between February 11 and February 17, 1997.

A total of 49 females and 52 males were selected to participate. Of those 101 initial students, six declined, leaving 95 who took part in the first phase of the data collection. A total of 87 students (44 females and 43 males) completed the second phase with 8 participants withdrawing. In order to ensure an equal number of data sets within each treatment cell, one male subject from the video treatment and two males subjects from the audio/video treatment, were randomly removed.
Descriptive data of the participants was also collected and included gender, age, and major area of study (Appendix M).

Research Design

The research design was based on a posttest only with control group design. According to Campbell & Stanley (1966), this design controls for history, maturation, testing, instrumentation, regression, selection, mortality, and interaction of selection and maturation, as sources of internal invalidity. In addition, the design controls for interaction of testing and X, as a source of external invalidity.

The variables identified for this study included the independent variables of instructional method and gender, and the dependent variable of level of performance on the psychomotor task as measured by the evaluation of the completed product for Test One, and following a time interval, Test Two. (Figure 3.1).

R	**Visual method**	**O**
R	**Verbal method**	**O**
R	**Visual & Verbal method**	**O**
R	**Control**	**O**

Figure 3.1. Posttest Only Control Group Design

Sampling Frame

The sampling frame for assigning the students to one of the three treatment groups and the control group involved stratified sampling procedures. The potential participants were divided based on the gender variable. Each stratum was treated independently and the inclusive subjects were randomly assigned to one of four intervention groups. A separate master participant list was generated alphabetically for the male and female participants. A random number table was used to establish the treatment for the participants based on their alphabetical order in their respective master list. The intent of this sampling frame was to reduce sampling variability and to insure that the gender variable was balanced throughout the treatments (Pedhazur & Schmelkin, 1991). The participants were selected from class rosters from those faculty agreeing to allow their students the opportunity to participate. After data collection began, those students declining to participate were deleted and additional students were selected. For example, if a male student assigned to the video treatment group declined to participate, another male student was recruited to fill the position. This provided the opportunity to ensure that the number of participants in each treatment was balanced as much as possible.

Study Procedures

The procedures for the data collection portion of the study were 1) Performance Task Introduction, 2) Treatment Intervention, 3) Performance Task, 4)Time Interval, 5) Performance Task, 6) Product Evaluation (Figure 3.2).

Performance Task Introduction. The introduction to the performance task included a description of the task, tools and materials identification, evaluation criteria (Appendix B). Based on pilot study outcomes, a sample of the finished product was also made available for inspection, to all treatments, during task performance.

Treatment Intervention. After introduction to the performance task, the participants received either a visual-only, verbal-only, or visual/verbal combined treatment, or were part of the control. All participants received the introduction to performance task and the slide sample.

Performance Task One. Performance Task One was completed by the participants as they received the treatment intervention. The performance task selected for the study involved manually creating a 35mm manipulated slide using the Gepe Mount system. The components of the manipulated slide include Gepe Mount, Kodalith slide mask, and a 35mm slide transparency. The tools needed to perform the task include an Xacto knife and a straight edge and the materials needed included Scotch tape. The procedures necessary for completing the task were taken from an instructional handout used for the Visual Communication Technology (VCT) 203 course taught at Bowling Green State University (OH) and are as follows:

1) Place gray half of Gepe Mount on a flat surface metal side up.

2) Affix Kodalith onto gray half of mount, emulsion side up.
   - emulsion side is dull or wrong reading side
   - align Kodalith into slots on metal portion of Gepe
   - secure with small piece of scotch tape
   - do not obscure image area with tape

3) Position transparency over the Kodalith window, emulsion side up.
   - emulsion side is dull, wrong reading, and curls towards emulsion

4) Make marks for cutting by scratching the film's emulsion with Xacto knife blade.

5) Use a straight edge and Xacto knife to score the emulsion side of the transparency where cut is desired (do not cut through transparency).

6) Fold/bend transparency on the scored line and break off excess portion of transparency film.

7) Align transparency on mask and secure with Scotch tape.

8) Remove any excess dust.

9) Affix white half of Gepe Mount to gray half, snap into place.

10) Visually check for alignment and make necessary corrections.

11) Label slide and place into slide tray, gray side facing you and upside down.

Performance Task Two. Following a time interval of approximately 11 days, the students were provided the tools and materials and again performed the manipulate slide task without task introduction, sample slide, or instructional intervention.

Evaluation. Evaluation of the completed manipulated slides was based on the following criteria: Labeling, Cycle Ability, Cleanliness of Image Area, Emulsion to Light Source, and Image Arrangement. A more detailed description of the criteria and scoring are provided in Figure 3.3.

The resulting Gepe Mount manipulated slides were evaluated by the researcher between the dates of 1-3 March, 1997. The evaluation portion of the study required that each slide be disassembled for inspection based on the evaluation criteria. For this reason, the slides were photocopied to produce a record of completion before evaluation began. The slides from each phase of data collection were placed in a container and randomly chosen for evaluation with phase one slides being evaluated first.

The evaluation protocol was as follows:

1) Randomly select completed slide from container.

2) Identify ID#, record on Evaluation and score accordingly.

3) Place slide in carousel on slide projector, cycle and score accordingly.

4) Compare image arrangement and orientation with sample and score accordingly.

5) Disassemble slide, determine orientation of emulsion for the Kodalith slide and the film transparency, and score accordingly.

6) Check for assembly order, correct assembly, check image area for fingerprints, scratches, and tape and score accordingly.

7) Calculate and record scores for each participant.

Labeling	The slide must be labeled with the participants ID# on the correct side and in the correct orientation.	Scored with a 0, 3, or 6.
Cycle Ability	The slide must successfully cycle from the slide tray to the projector and back to the slide tray.	Scored with a 0 or a 4.
Clearness of Image Area	The image area (glass windows, film transparency, and Kodalith slide mask) must be free of scratches, tape, and fingerprints that will impede projection. In addition, the Kodalith Mask must be under the metal clips of the Gepe Mount and both the transparency and the mask must be assembled in the proper order and be secured with tape.	Scored 0-20, with a 2 point deduction for each occurrence of scratches, tape, or fingerprints in image area, and a 2 point deduction for failure to place the slide mask under the clips of the Gepe Mount, for failure to secure the mask with tape, for failure to secure the film transparency with tape, and for failure to assemble the film in the correct order.
Emulsion To Light Source	The emulsion of the slide transparency and the Kodalith slide mask must be secured in the Gepe Mount so that the emulsion side will be toward the light source.	Scored 0, 2, or 4, with 2 points given for correct orientation of the slide transparency and 2 point for correct orientation of the Kodalith slide mask.
Image Arrangement	The slide transparency must be arranged in the Kodalith slide window in a manner such that the edge of the slide transparency is square with the edge of the Kodalith slide window.	Scored 0, 3, or 6, with 3 points given for film image located in the left half of the slide when viewed from the gray half of the Gepe Mount with the image right side up, and 3 points for film transparency image orientation such that the pillars in the image progress from smallest to largest, left to right.

Figure 3.2. Evaluation Criteria For Scoring Gepe Mount Slide.

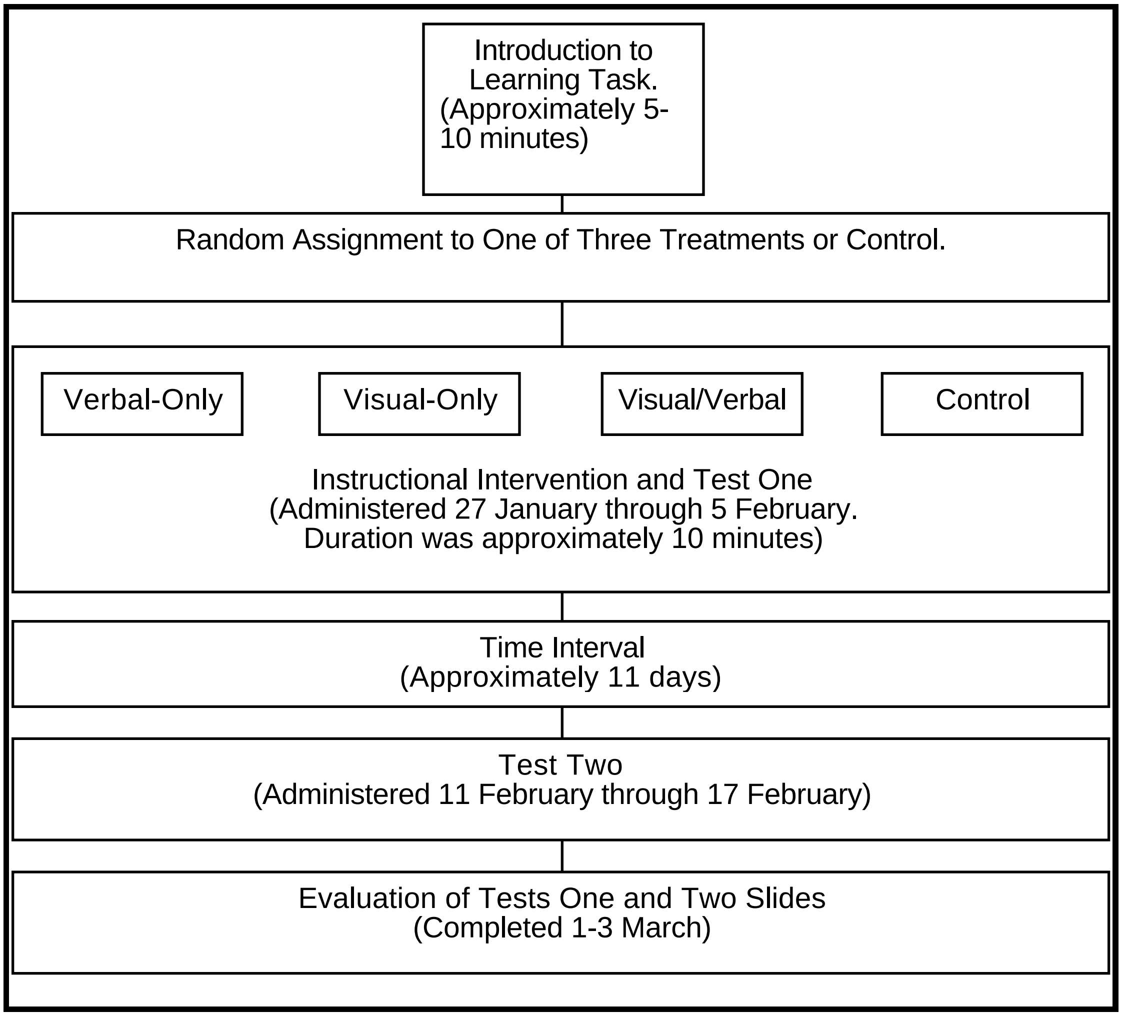

Figure 3.3. Data Collection Procedures.

Validation and Reliability Procedures

The two components of the study created by the researcher that required validation included the instructional media script, and the evaluation criteria and scoring system. The media script was edited and evaluated by two, independent expert reviewers. The reviewers were selected on the basis of their experience with video production. Dr.

Vince Childress, formerly of Virginia Tech and Mr. Tom Hergert, of Virginia Tech, edited the script for technical and procedural content, clarity, accuracy, and readability. Programming assistance was provided by Mr. Michael Mitchell, a professional multimedia developer. For task evaluation, an evaluation form was developed and modified based on pilot study outcomes (Appendix K for Test One and Appendix L for Test Two). The instrument was then reviewed by Dr. D. K. Trautman of Bowling Green (OH), an independent subject matter expert. Based on input from the reviewer, the instrument was modified to distribute point values for each of the criteria based on its importance to the finished product.

Treatment

Three instructional treatments and one control were incorporated. Treatment One was a verbal-only presentation of the performance task instructions. Treatment Two was a visual-only presentation of the instructional task. Treatment Three was a combination of the visual/verbal formats (Appendix A). The treatments were comparable in regards to substantive content and instructional time. The control group received no instructional intervention. All participants received the Introduction to Task handout (Appendix B).

Treatment Development. The CBI materials were developed using *Macromedia Authorware* software. To ensure content consistency in the methods of instruction, a procedural script was developed that served as a guide for producing the instructional media (Appendix A).

The script included media production information and technical and procedural information necessary to complete the performance task. The verbal-only mode consisted of audio CBI and the visual-only method consisted of video CBI. The visual/verbal combined CBI utilized both the visual-only and the verbal-only modes to concurrently present the information. The visual/verbal CBI was developed first and then two copies were made. Within one copy the audio was disabled which produced the video-only CBI. Within the second copy the video was replaced with the corresponding audio which produced the audio-only CBI.

The CBI materials were developed on the Macintosh platform. Software used in the development included *Authorware, Premiere,* and *SoundEdit* software. Hardware used in the development included a *Macintosh 540c PowerBook* and a *Macintosh Quadra 950*. Video footage was captured using a Hi8 format video camera and audio was capture using the standard Macintosh microphone. Video talent, audio talent, and technical direction was provided by the researcher. A videographer was obtained to shoot the required video footage. The CBI instructional methods were presented using a *Macintosh 540c PowerBook.*

Data Collection

Participants were selected from their scheduled laboratory work time based on availability. At the study location, each participant was asked to read and sign the Participation Consent Form (Appendix H), verify their ID#, and were then given the Introduction to Learning Task Handout and were instructed to review the document (Appendix B). After reviewing, the participant was seated at a table containing the tools, materials, sample slide, and applicable treatment. The participants completed the Gepe Mount performance task while receiving one of three treatments or the control group non-treatment. Evaluation of the performance was based on the direct product approach. The researcher for this study was responsible for administering the treatment interventions.

Data Analysis

The resulting data from the posttest-only control group design were analyzed using analysis of variance. The variables include gender and media type and are represented in Figure 3.4. The level of significance was set at the .05 level.

	Visual	
Verbal	Vs & Vr	Vr
	Vs	Control

Figure 3.4. Delivery Mode Variables.

Pilot Study

A pilot study was conducted to identify and correct potential problem areas with the CBI and the study methodology. A group of eight undergraduate and graduate students were recruited to participate. The pilot study participants were students enrolled in EDSTDS 730, Technological Activities for Teachers of Exceptional Children, taught at

The Ohio State University. The pilot study procedures were consistent with the proposed main study procedures using both the treatments and the control. Analysis of the pilot study identified two deficiencies in the initial protocol and support materials that involved the instructions for the CBI treatments and instructions for the control group.

From the pilot study, it was determined that the Gepe Manipulated Slide activity could not be completed by the control group without instruction. This suggested that the complexity of the Gepe task nulled the need for a control group. In order to maintain the integrity of the research design, the decision was made to provide all groups with a completed sample of the finished slide for examination during the instructional interventions.

Summary

Chapter Three provided a description of the methodology employed in an attempt to test the research questions. In addition, a description of the participants, data collection procedures, data analysis, and performance task was provided.

CHAPTER IV
Results of the Study

Chapter Four presents the results of the study. A description of the participants is provided as well as the results of the primary analysis of the research hypotheses and secondary analyses of study data.

Description of the Participants

Potential participants were selected from class rosters for students enrolled in courses offered in the Industrial Technology Department of Bemidji State University. The faculty member responsible for each class was contacted to request permission for their students to participate. The resulting sample was generated from class rosters provided by those faculty agreeing to allow their students the opportunity to participate during their scheduled laboratory work time.

The sampling frame for assigning the students to one of the three treatment groups and the control group involved stratified sampling procedures. Using the class rosters from those faculty who allowed their students the opportunity to participate in the study, a separate master participant list was generated alphabetically for the male and female participants. A random number table was used to establish the treatment order of video-only, audio/video, control, and audio-only. The repeating treatment order was then applied to the master list of male and female participants, and based on their alphabetical order this determined the treatment they would receive.

Prior to and during data collection, those students declining to participate were removed from the list and additional students from the master list were selected. For example, if a male student assigned to the video-only treatment group declined to participate, another male student was recruited to fill the position. This provided the opportunity to ensure that the gender in each treatment was generally balanced. Selection of the participants to replace drop-outs was based on availability of the replacement to participate during their scheduled class time or availability to participate on a scheduled basis.

The sample was drawn from the population of students enrolled in Industrial Technology courses offered Winter quarter 1996. The total number of students enrolled in Industrial Technology courses on the Bemidji campus Winter quarter 1996-97 was 805. Based on the availability of the class for participation, a total of 49 females and 52 males were selected to participate, although, 6 of the 101 participants, declined, leaving 95 who took part in the first phase of the data collection. A total of 87 students (44 females and 43 males) completed the second phase with eight participants withdrawing. Reasons for withdrawing from the study included one participant who was injured and seven who were unable to participate due to time conflicts with work or school. In order to ensure an equal number of data sets for analysis, based on gender between and within treatment cells, the Test scores for one female participant from the audio-only treatment, one female and one male participant from the video-only treatment, one female and two male participants from the audio/video treatment, and one female from the control, were randomly dropped prior to data analysis. Analysis for this study was conducted using data generated from 40 female and 40 male participants.

Data Collection

The participants involved in this research were enrolled as undergraduate students in the Industrial Technology Department, College of Professional Studies, of the Bemidji State University, Bemidji Minnesota. Collections dates for the first phase occurred between January 27 and February 5, 1997. Data collection for the second phase occurred between February 11 and February 17, 1997. Descriptive data of the participants were also collected and included gender, age, and major area of study (Appendix M).

The data collection for each participant was conducted in the following manner. The researcher visited each class independently to explain the nature of the research, answer questions, and invite students to participant in the study. Those students willing to participate were asked to review and sign the Participant Consent Form (Appendix H). When possible, data collection was conducted during the students' scheduled laboratory work time, however, instances did occur that necessitated participation at other times. When this situation occurred, the participant provided an alternate time for participation. The order for participation was obtained by consulting, on an alternating basis, the Master List for Female and Male participants then selecting the first available person on the list to participate. Separate lists for male and female participants were generated to ensure an equal distribution of gender between and within treatments. Students identified, who did not agree to participate were asked to provide a reason for declining and then thanked for their time. If they agreed, participants were then given a copy of the Introduction to Learning Task for review (Appendix B). Participants were given the opportunity to ask questions before they received any intervention. Participants were then seated at a table that held a laptop computer with the computer-based instructions, a copy of the Introduction to Learning Task (Appendix B), sample slide, scotch tape, ruler, Xacto knife, color pencil, Gepe slide, Kodalith slide mask, and slide transparency. They were informed that those items made available on the table could be used to perform the specified task. The laptop computer was removed from the table top for those participants in the control group.

Intervention. During intervention the researcher vacated the room to allow each participant the opportunity to complete the task without interruption. Upon completion of the intervention, participants were asked not to discuss the nature of the instruction or performance task with others and then were thanked for their time. Following the intervention and after each participant left the room, the researcher examined the resulting slide for the participants four digit identification number (ID#). If no number was found, the researcher labeled the white half of the Gepe slide, using a different color pencil, with the participants four digit ID#. The correct location for the ID# was on the gray half of the Gepe Mount. Labeling the white half ensured that the resulting slide would be identifiable for evaluation.

The primary data collected for comparative analyses were the participant scores on Tests One and Two. The Tests involved assembling a slide, composed of a Kodalith slide window and a color film transparency using a Gepe Mount Manipulated Slide. Test One was administered during the treatment intervention and Test Two was administered following a time interval. The mean time between Tests One and Two for all participants was

11.1 days. More descriptive information concerning the time between Tests can be found in Appendix P. The resulting Gepe Mount manipulated slides were evaluated by the researcher between the dates of 1-3 March, 1997. The evaluation portion of the study required that each slide be disassembled for inspection based on the evaluation criteria. For this reason, the slides were photocopied to provide a visual record of completion for each participant before evaluation of the slides began. The slides from each phase of data collection were placed in a container and randomly chosen for evaluation with Test One slides being evaluated first.

Evaluation. The evaluation protocol was as follows: 1) Randomly select completed slide from container; 2) Identify ID#, record on Evaluation Form (Appendix K for Test One, Appendix L for Test Two) and score accordingly; 3) Place slide in carousel on slide projector, cycle and score accordingly; 4) Compare image arrangement and orientation with sample and score accordingly; 5) Disassemble slide, determine orientation of emulsion for the Kodalith slide and the film transparency, and score accordingly; 6) Check for assembly order, correct assembly, check image area for fingerprints, scratches, and tape and score accordingly; and 7) Calculate and record scores for each participant.

The evaluation criteria and protocol for Test Two slides was consistent with that of Test One. Evaluation of Test Two slides was completed using the Product Evaluation Form for Test Two (Appendix L). A different form was used to evaluate and record the scores in order to avoid scoring bias on the part of the evaluator. In addition, the treatment and gender variables were not identified during evaluation of the slides for Test One or Two.

Secondary Data. Data, other than descriptive information, collected from those participants in the audio, video, and audio/video treatment groups included the time spent within each section of instruction, the number of reviews in a section, and the total time for completion (Appendix O). The total time on task for the control group participants was collected using a stop watch. In addition, those participants receiving instruction were asked a series of questions pertaining to their use and perception of computers and computer-based instruction (Appendix N).

Results

The study was designed to investigate the effect of visual-only, verbal-only, and visual-verbal instructional methods, utilizing Computer-based instruction (CBI) as the delivery mode, on the performance of psychomotor skills and knowledge. More specifically, do visual-only, verbal-only, or a combination of visual-verbal instructional methods which incorporate the use of CBI significantly increase performance in the psychomotor domain? The instructional methods employed were a video-only, audio-only, and an audio/video presentation of instructions for completing a manipulate slide using a Gepe Mount Slide.

The analysis results for this study supported one of the five hypotheses but did not provide support for the remaining four. An ANOVA statistical analysis of the Test One score produced results for the main effects of gender and treatment. The treatment groups were audio-only, video-only, audio/video, and control instructions for assembling a Gepe Mount Slide. Test One involved assembly of the Gepe slide during instruction and Test Two involved assembly of the slide without instruction, following a time interval. The evaluation of the slide provided by each participant in Tests One and Two was based on the evaluation criteria and recorded on the evaluation instrument (Appendix K for Test One and Appendix L for Test Two). Mean scores for Tests One and Two by gender and treatment are presented in Appendix Q.

Data analysis was conducted using SPSS 6.1.1, for the Macintosh. Analyses employed included an ANOVA and the Student-Newman-Keuls test with a significance level of .05. The ANOVA was used due to the advantages in analyzing the effects of multiple variables in a factorial design. The Student-Newman-Keuls test was used because the test pools variance across all pools and uses all groups in the analysis.

Hypothesis One. The level of performance of the subjects receiving the visual-verbal combined treatment will be greater than the subjects receiving the visual-only or verbal-only treatments.

The Test One score of all participants were subjected to an ANOVA with the dependent variable of Test One score and the independent variable treatment. The F-statistic produced indicated a significant difference in the level of performance based on treatment (Table 4.1).

Table 4.1. ANOVA Table For Male and Female Participants, Test One Score.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Treatment	3	906.74	302.25	16.15	.00
Explained	3	906.74	302.25	16.15	.00
Residual	76	1421.95	18.71		
Total	79	2326.69	29.48		

A One-Way ANOVA was used to identify statistical differences in the level of performance between audio-only, video-only, and audio/video treatment groups with the Test One score as the dependent variable. The F-statistics generated indicated there was a significant difference in the level of performance between treatment groups (Table 4.2).

Table 4.2. One-Way ANOVA Table For Male & Female Participants, Audio, Video, and Audio/Video Treatments, Test One.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	2	161.20	80.60	4.04	.02
Within Groups	57	1137.40	19.95		
Total	59	1298.60			

Further analysis of the treatment groups, with the Test One score as the dependent variable, using the Student-Newman-Keuls test with a significance level of .05, produced the results presented in Table 4.3. The test identified the significant difference between treatments obtained using the One-Way ANOVA (Table 4.2) was evident between the audio-only and audio/video treatments and between the video-only and audio/video treatments.

Table 4.3. Student-Newman-Keuls Test With A Significance Level of .05. Male & Female Participants, Audio, Video, and Audio/Video Treatments, Test One

Mean	Treatment	Audio	Video
23.30	Audio	----	NS
23.80	Video	NS	----
27.00	Audio/Video	P<.05	P<.05

Hypothesis One was accepted at the .05 level. Participants in the audio/video treatment group performed significantly better than the audio-only treatment group and the video-only treatment group. These findings suggest that the use of multiple presentation formats can improve learning outcomes and performance of psychomotor objectives.

Hypothesis Two. The level of performance for males receiving the visual-only treatment will be greater than the males receiving the verbal-only treatment.

The Test One scores of male participants in the audio-only treatment and the video-only treatment groups were analyzed using a One-Way ANOVA. The resulting F-statistic indicated there was no significant difference in the level of performance for Test One by males between the audio-only and video-only treatment groups (Table 4.6).

Table 4.4. One-Way ANOVA Table For Male Participants, Audio-Only and Video-Only Treatments, Test One.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	1	2.45	2.45	.13	.72
Within Groups	18	344.50	19.14		
Total	19	346.95			

Hypothesis Two was rejected at the .05 level. The level of performance for male participants on Test One did not differ significantly between the audio-only treatment group and the video-only treatment group. These findings suggest that the use of a visual-only or verbal-only instructional method does not significantly improve learning outcomes and performance of psychomotor objectives for male learners.

Hypothesis Three. The level of performance for females receiving the verbal-only treatment will be greater than the females receiving the visual-only treatment.

The scores from Test One for female participants in the audio-only treatment and the video-only treatment groups were analyzed using a One-Way ANOVA. The resulting F-statistic indicated there was no significant difference in the level of performance on Test One between female participants in the audio-only and video-only treatment groups (Table 4.7).

Table 4.5. One-Way ANOVA Table For Female Participants, Audio-Only and Video-Only Treatments, Test One.

Female Test One	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	1	.45	.45	.02	.88
Within Groups	18	372.10	20.67		
Total	19	372.55			

Hypothesis Three was rejected at the .05 level. The level of performance on Test One for female participants did not differ significantly between the audio-only and video-only treatment group. These findings suggest that the use of a visual-only or verbal-only instructional method does not significantly improve learning outcomes and performance of psychomotor objectives for female learners.

Hypothesis Four. The level of performance for males receiving the visual-only treatment will be greater than the females receiving the visual-only treatment.

The Test One scores of male participants in the video-only treatment and female participants in the video-only treatment group were analyzed using a One-Way ANOVA. The resulting F-statistic indicated there was no significant difference in the level of performance between males in the video-only treatment group and females in the video-only treatment group (Table 4.8).

Table 4.6. One-Way ANOVA Table For Male & Female Participants, Video-Only Treatment, Test One.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	1	20.00	20.00	1.28	.27
Within Groups	18	281.20	15.62		
Total	19	301.20			

Hypothesis Four was rejected at the .05 level. The level of performance between male participants in the video-only treatment group did not differ significantly from the level of performance of the females in the video-only treatment group. These findings suggest a visual-only presentation of psychomotor content to male and female learners will affect learning outcomes and performance equally.

Hypothesis Five. The level of performance for females receiving the verbal-only treatment will be greater than the males receiving the verbal-only treatment.

The Test One scores of female participants in the audio-only treatment and male participants in the audio-only treatment group were analyzed using a One-Way ANOVA. The resulting F-statistic indicated no significant difference in the level of performance between females in the audio-only treatment group and males in the audio-only treatment group (Table 4.9).

Table 4.7. One-Way ANOVA Table For Male & Female Participants, Audio-Only Treatment, Test One.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	1	28.80	28.80	1.19	.29
Within Groups	18	435.40	24.19		
Total	19	464.20			

Hypothesis Five was rejected at the .05 level. The level of performance of female participants in the audio-only treatment group did not differ significantly from the performance of the male participants in the audio-only treatment group. These findings suggest a verbal-only presentation of psychomotor content to male and female learners will affect learning outcomes and performance equally.

Secondary Analysis

A secondary analysis of the study data attempted to determine the efficacy of the audio, video, and audio/video instructional methods and the level of performance after a time interval. An attempt was also made to identify the evaluation criteria for Test One that contributed to the difference in performance between the audio, video, and audio/video treatment groups. Additional data presented include the participant responses to the survey questions relating to computer and computer-based instruction use.

To determine the effects of the instructional method and gender on performance after a time interval, a secondary analysis of the study data involved the score for Test Two. Test Two scores for male and female participants in the audio, video, and audio/video treatment groups were subjected to an ANOVA. The resulting analysis indicated no significant difference in the level of performance, after a time interval, between audio-only, video-only, and audio/video treatment (Table 4.10). These findings suggest neither the presentation mode, nor gender significantly affects learning outcomes and performance for psychomotor tasks.

Table 4.8. One-Way ANOVA Table For Audio, Video, and Audio/Video Treatment Groups, Test Two Score.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	2	179.23	89.62	2.28	.11
Within Groups	57	2243.35	39.36		
Total	59	2422.58			

While Hypothesis One was accepted at the .05 level using the score from Test One, the question arose as to which evaluation criteria could the difference between treatments be attributed? In order to identify the criteria responsible for the difference in the level of performance between the audio-only, video-only, and audio/video treatment groups, the scores from four of the five criteria areas that produced the composite score for Test One were subjected to an ANOVA (Table 4.9). The evaluation criteria (actual performance tasks used to evaluate the slide) combined to produce the test scores were: Arrangement; Emulsion; Image; Labeling; and Cycling. The evaluation criteria of Cycling was excluded in the analysis due to all participants receiving an identical score. The resulting F-statistics indicted that there was significant difference in the level of performance between treatments for Test One based on the Image and Labeling criteria, but no significant difference in the level of performance between treatment based on the Emulsion and Arrangement criteria.

Table 4.9. ANOVA Table For Test One Criteria For Participants in the Audio, Video, and Audio/Video Treatment Groups.

Test One Criteria	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Covariates	4	8.64	2.16	3.72	.01
Arrangement	1	.01	.01	.02	.90
Emulsion	1	.01	.01	.01	.91
Image	1	5.69	5.69	9.80	.003
Labeling	1	2.45	2.45	4.24	.04
Main Effects					
Gender	1	.27	.27	.47	.47
Explained	5	8.64	1.73	2.97	.02
Residual	54	31.36	.58		
Total	59	40.00	.68		

The scores for the Labeling criteria from Test One were subjected to an ANOVA to identify differences in performance based on treatment. The results presented in Table 4.10, indicated a significant difference in the level of performance between treatment based on the Labeling criteria. Further analysis using the Student-Newman-Keuls test with a significance level of .05 identified the difference in performance based on the Labeling criteria was significant between the audio-only and the audio/video treatment and between the video-only and audio/video treatment(Table 4.11). These findings suggest that presenting information regarding the specific location of a variable, such as an ID#, a multiple presentation mode is more effective.

Table 4.10. One-Way ANOVA Table For the Labeling Score From Test One For Male & Female Participants in the Audio, Video, and Audio/Video Treatment Groups.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	2	38.10	19.05	7.56	.001
Within Groups	57	143.55	2.52		
Total	59	181.65			

Table 4.11. Student-Newman-Keuls Test With A Significance Level of .05. For the Labeling Score From Test One For Male & Female Participants in the Audio, Video, and Audio/Video Treatment Groups.

Mean	Treatment	Audio	Video
3.60	Audio	----	NS
2.70	Video	NS	----
4.65	Audio/Video	P<.05	P<.05

The scores for the Image criteria from Test One were subjected to an ANOVA to identify differences in performance based on treatment. The results presented in Table 4.12, indicated a significant difference in the level of performance between treatment based on the Image criteria. Further analysis using the Student-Newman-Keuls test with a significance level of .05 identified the difference in performance based on the Image criteria was significant between the audio-only and the audio/video treatment (Table 4.13). The findings suggest when presenting information concerning the relationship of objects to one another, a visual representation will enhance performance.

Table 4.12. One-Way ANOVA Table For the Image Score From Test One For Male & Female Participants in the Audio, Video, and Audio/Video Treatment Groups.

	DF	Sum of Squares	Mean Square	F Ratio	Sig. of F
Between Groups	2	138.53	69.27	5.11	.009
Within Groups	57	772.40	13.55		
Total	59	910.93			

Table 4.13. Student-Newman-Keuls Test With A Significance Level of .05. For the Image Score From Test One For Male & Female Participants in the Audio, Video, and Audio/Video Treatment Groups.

Mean	Treatment	Audio	Video
9.90	Audio	----	NS
12.10	Video	NS	----
13.60	Audio/Video	P<.05	NS

Upon completion of the treatment intervention, participants in the audio, video, and audio/video treatment groups were requested to respond to a series of questions relating to their use of computers and computer-based instruction in their school and work environment (Table 4.14). Six questions were used that employed a Likert-type response option of four choices. Question One referred to computer use; questions Two and Three referred to computer-based instruction; and questions

Four, Five, and Six referred to the Gepe Mount computer-based instruction. Responses for the 60 participants in the instructional treatment groups were used for the analysis. Comparisons of the response means for the survey questions by gender and treatment are presented in Graphs 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6.

Table 4.14. Survey Questions and Response Options for Participants in the Audio, Video, and Audio/Video Treatment Groups.

Response Options for Questions One-Three	Never 1	Seldom 2	Often 3	Always 4
1) How often do you use a computer for school-related work?				
2) How often do you use computer-based instruction (similar to the Gepe Mount instruction) for school-related work?				
3) If available, how often would you elect to use Computer-Based Instruction for school related work?				
Response Options for Questions Four-Six	**Strongly Disagree 1**	**Disagree 2**	**Agree 3**	**Strongly Agree 4**
4) The instructions for assembling the Gepe Mount slide were clear and understandable.				
5) The instructions provided useful and adequate information to complete the Gepe Mount task.				
6) If given a choice of instructional methods, I would prefer the type of instruction I received for the Gepe Mount task.				

Question One. How often do you use a computer for school-related work?

Response Options: Never=1, Seldom=2, Often=3, Always=4

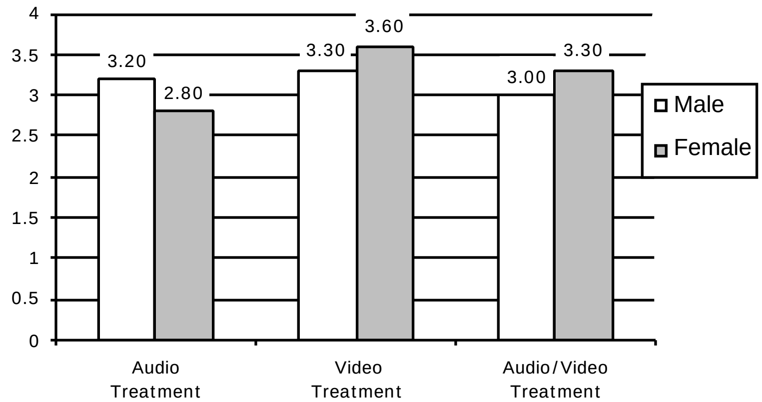

Figure 4.1. Mean Response to Survey Question One by Gender and Treatment.

Question Two. How often do you use computer-based instruction (similar to the Gepe Mount instruction) for school-related work?

Response Options: Never=1, Seldom=2, Often=3, Always=4

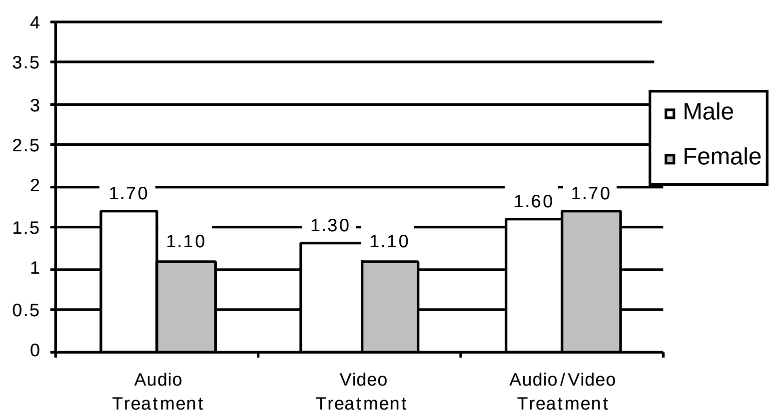

Figure 4.2. Mean Response to Survey Question Two by Gender and Treatment.

Question Three. If available, how often would you elect to use Computer-Based Instruction for school related work?

Response Options: Never=1, Seldom=2, Often=3, Always=4

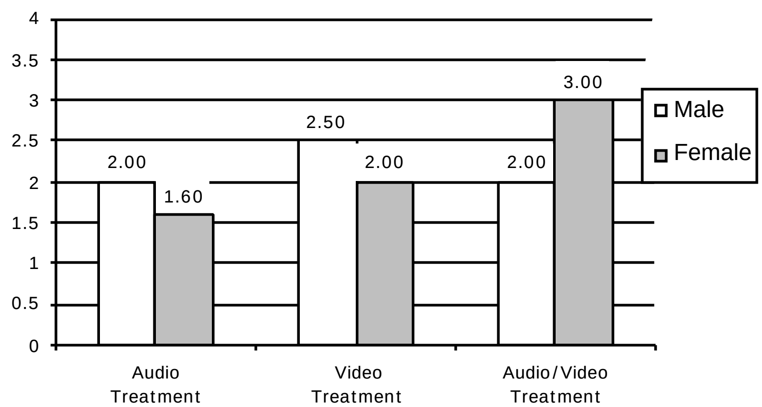

Figure 4.3. Mean Response to Survey Question Three by Gender and Treatment.

Question Four. The instructions for assembling the Gepe Mount slide were clear and understandable.

Response Options: Strongly Disagree=1, Disagree=2, Agree=3, Strongly Agree=4

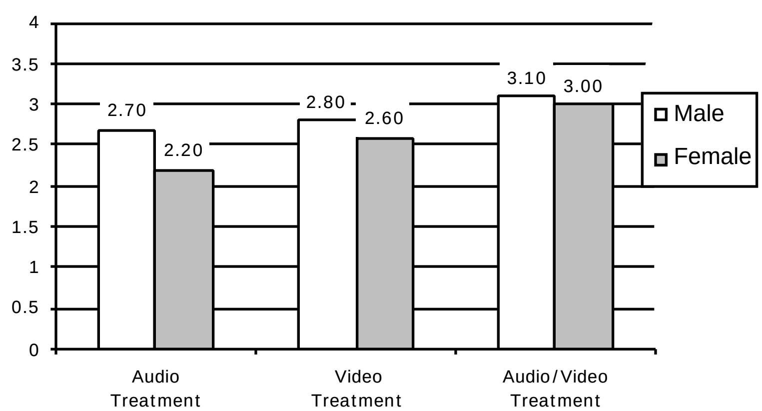

Figure 4.4. Mean Response to Survey Question Four by Gender and Treatment.

Question Five. The instructions provided useful and adequate information to complete the Gepe Mount task

Response Options: Strongly Disagree=1, Disagree=2, Agree=3, Strongly Agree=4

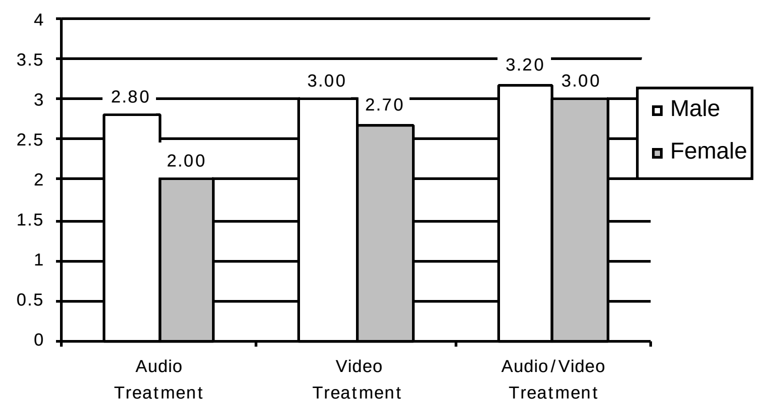

Figure 4.5. Mean Response to Survey Question Five by Gender and Treatment.

Question Six. If given a choice of instructional methods, I would prefer the type of instruction I received for the Gepe Mount task.

Response Options: Strongly Disagree=1, Disagree=2, Agree=3, Strongly Agree=4

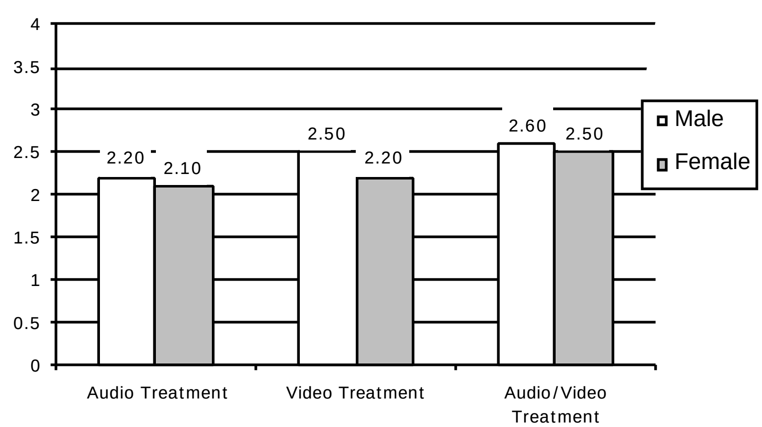

Figure 4.6. Mean Response to Survey Question Six by Gender and Treatment.

Group means (N=60) for each question were examined and provided the following. Participant response to question One (mean=3.20) indicated frequent use of computers for school and/or work. While the participants were utilizing the computer for school and work related activities, their response to question Two (mean=1.42) indicated their experience with computer-based instruction was limited. Response to question Three (mean=2.13) concerning the participants' willingness to use computer-based instruction indicated a willingness to use CBI more often if available.

The response mean to question Four was 2.73. Based on treatment, responses indicated a lower level of clarity and understanding of instruction with audio-only (mean=2.45), somewhat higher level with video-only (mean=2.70), and greater clarity and understanding with audio/video instruction (mean=3.05). Response to question Five (mean=2.78) concerning the usefulness and adequacy of the instruction paralleled the response to question Four. The responses based on audio-only (mean=2.40), video-only (mean=2.85), and audio/video (mean=3.10), treatment indicated instruction was more understandable when presented via audio/video format. Response to question Six (mean=2.35) provided information concerning the participants willingness to use a computer-based instructional method similar to the treatment they received. Responses based on treatment (audio-only, mean =2.15), video-only, mean=2.35), and audio/video, mean =2.55) were consistent to those from questions Four and Five indicating those participants who received the audio/video instruction had a higher level of satisfaction with the instruction.

Questions Four, Five, and Six dealt with the instruction received by the participants. Response means indicated the level of understanding and satisfaction with the instruction was greater by those participants receiving the audio/video treatment and less by those receiving the video-only, and audio-only treatments respectively.

Summary

This chapter presented the results from the primary and secondary data evaluation and analysis of the relationship between presentation mode and psychomotor performance based on direct product evaluation. Information concerning the effect of time between instruction, instructional method, and psychomotor performance, and information concerning participants use and satisfaction of computers and computer-based instruction was included.

Primary analysis suggested:

1. There was a significant difference in the level of performance between those participants receiving the audio/video treatment versus those receiving the audio-only or video-only treatment.

2. There was no significant difference in the level of performance for males receiving the visual-only treatment versus males receiving the verbal-only treatment.

3. There was no significant difference in the level of performance for females receiving the verbal-only treatment versus the females receiving the visual-only treatment.

4. There was an no significant difference in the level of performance for males receiving the visual-only treatment versus the females receiving the visual-only treatment.

5. There was no significant difference in the level of performance for females receiving the verbal-only treatment versus the males receiving the verbal-only treatment.

A secondary analysis of the study data attempted to determine the efficacy of the audio, video, and audio/video instructional methods on the level of performance after a time interval. An attempt was also made to identify the evaluation criteria for Test One that contributed to the difference in performance between the audio, video, and audio/video treatment groups. Additional data presented include the participant responses to the survey questions relating to computer and computer-based instruction use.

Secondary analysis suggested:

1. That the difference in the level of performance on Test One between the video-only, and audio/video treatment groups could be attributed to the Labeling criteria.

2. That the difference in the level of performance on Test One between the audio-only, and audio/video treatment groups could be attributed to the Image and Labeling criteria.

3. There was no significant difference in the level of performance following a time interval, between the audio-only, video-only, and audio/video treatment groups.

Chapter 5 will present a summary and discussion of study findings and implications for educators and media developers. In addition, limitations of the study and recommendation for further research are provided.

CHAPTER V
Summary of the Study, Discussion, Recommendations, and Conclusions

The chapter contains a summary of the present investigation, findings, conclusions, and implications for computer-based instructional development for psychomotor tasks and research.

Summary of the Study

Technology, in the form of computer hardware and software, available to educators, has contributed to the increased use of computer-based instruction (CBI). Educators have the opportunity to integrate existing CBI in their classroom or develop instruction for specific discipline-related content and objectives. CBI has the potential to present information in a multitude of formats such as “verbal” and “visual” using sound, text, pictures, animation, and video in an environment that can be interactive and require structured or flexible navigation. The versatility of CBI provides an increased level of potential for presenting affective, cognitive, and psychomotor learning objectives. In addition, well constructed media can provide consistent presentation of information regardless of the liabilities or influence of the educator.

The attributes of CBI are such that appropriate application can be beneficial to the learner, but with the increased capacity and variability for presenting information, the opportunities for inappropriate application increase as well. Developing and applying CBI in an appropriate manner requires recognition and understanding of the elements which influence the teaching-learning environment.

In technology education classrooms, the hands-on instructional approach is an integral component affecting learning outcomes in the affective, cognitive, and psychomotor domains. In order to effectively integrate computer-based instruction for activities within the psychomotor domain, an educator must select appropriate instructional methods suitable for the content and learner.

Research provides a useful source of information relating to appropriate instructional methods, but early media research tended to focus on comparative investigations of traditional instruction and new instructional technologies. However, this approached focused more on the technology as the delivery vehicle, with little emphasis placed on the learner, content, and the instructional method.

An analysis of media research, conducted by Clark & Sugrue (1989), indicated that learning which occurs from well constructed media presentations can be attributed to three variables--learning task type, individual learner traits, and instructional methods. The intent of this investigation was to develop a study which identified and controlled the variables related to task, learner, and instructional method. The purpose of this study was to investigate the efficacy of three instructional methods for a psychomotor performance task for male and female college students, thus addressing the three variables proposed by Clark & Sugrue (1989).

In order to investigate the efficacy of verbal, visual, and verbal/visual CBI for psychomotor learning objectives, the instructions for a performance task were converted to audio, video, and audio/video formats. Five research hypotheses addressing gender and instructional method were proposed and investigated.

Hypothesis One stated that the level of performance of the subjects receiving the visual-verbal combined treatment would be greater than the subjects receiving the visual-only or verbal-only treatments. Hypothesis Two stated that the level of performance for males receiving the visual-only treatment would be greater than the males receiving the verbal-only treatment. Hypothesis Three stated that the level of performance for females receiving the verbal-only treatment would be greater than the females receiving the visual-only treatment. Hypothesis Four stated that the level of performance for males receiving the visual-only treatment would be greater than the females receiving the visual-only treatment. Hypothesis Five stated that the level of performance for females receiving the verbal-only treatment would be greater than the males receiving the verbal-only treatment.

Three computer-based instructional methods were developed to present content for assembling a Gepe Mount manipulated slide. The selection of the Gepe Mount task was, in part, a response to earlier studies such as those conducted by Powell & Harris,(1990) and Green & Powell (1988). Their research suggested that different instructional formats did not affect SCUBA-diving performance, and that psychomotor performance, in this case marble placement, was not contingent upon the instructional method. A possible weakness with the latter study concerns the performance task of marble placement. Participants were evaluated based on the placement of marbles in a specific location, and it is quite possible that the criterion used for evaluation may have been more reliable on cognitive performance due to the simplicity of manipulating or placing a marble. In an attempt to provide more adequate discrimination between treatments, the Gepe Mount task was selected because of the complex technical or psychomotor performance required for its completion.

The three methods used to present the procedural task included an audio-only presentation, a video-only presentation, and an audio/video combined presentation. Participants were randomly assigned, based on gender, to one of three treatment groups or the control (no instruction) group. Before intervention, all participants reviewed the Introduction to Learning Task handout (Appendix B) and were provided a sample of an assembled Gepe Mount slide for review during intervention. While receiving their respective treatment, participants completed the Gepe Mount manipulated slide which provided the Test One data. Test Two data were obtained following a time intervention of approximately 11 days. Participants were again asked to complete the Gepe Mount task without the handout, sample, or instructions related to the task. Scores obtained from a direct product evaluation of the completed slides resulting from both Tests One and Two were used to measure the efficacy of the three instructional methods. The data were analyzed using an ANOVA, and where appropriate, a Student-Newman-Keul to determine difference in the level of performance based on the scores from Test One and Two. A post-intervention survey was administered to the audio, video, and audio/video treatment groups via the computer to identify computer and CBI use of the participants, and to identify their level of satisfaction with the instruction.

Discussion

The results of testing Hypothesis One indicated that there was a significant difference in the level of performance of participants receiving the audio/video treatment over those receiving the audio-only or video-only treatment. In addition, secondary analysis indicated that the difference in the level of performance on Test One between the audio-only, video-only, and audio/video treatment groups could be attributed to the Labeling and Image evaluation criteria. More specifically, there was a significant difference in the level of performance between the video-only and audio/video treatment based on the Labeling criteria; and there was a significant difference in the level of performance between the audio-only and audio/video treatment based on both the Image and Labeling criteria.

The Labeling criteria evaluated performance based on the placement of a variable, (ID#) with a value known only to the participant, in a specific location. The information required to convey this instruction is both factual (recording one's ID# in a specific location) and spatial (the location). The mean total scores on Test One for the video-only and audio/video treatments were 20.30 and 27.40; and the mean score for Labeling was 2.70 and 4.65 respectively. This suggests that the difference in the level of performance could be attributed to the ineffectiveness of the visual-only instruction to convey the factual information concerning the specific variable of ID#, and to some degree, the location. The audio/video treatment provided the information in a redundant verbal/visual format, thus conveying a more complete representation of the specific task. This suggests that the verbal component of the audio/video treatment contributed to providing information in the necessary format as required for comprehension.

In addition, there was a significant difference in the level of performance between the audio-only and audio/video treatment based on both the Image and Labeling criteria. The Image criteria evaluated the performance based on the arrangement of the slide components in the correct order in the Gepe Mount. The mean scores for Test One and for the Image and Labeling criteria were 27.40 and 23.30, 13.60 and 9.90, and 4.65 and 3.60 respectively, for the audio/video and audio-only treatment groups. These findings suggest that presenting the location, order, and placement of physical components in a verbal/visual manner conveys the information in a more understandable form than the verbal-alone presentation. Furthermore these findings are consistent with results from earlier related studies suggesting that learning benefits can be gained when audio/video methods combine relevant verbal and visual information to convey spatial objectives rather than rely on verbal-only approaches to instruction.

Hypotheses Two, Three, Four, and Five dealt with gender and instructional methods for teaching psychomotor tasks. While there is well documented research that contends that males and females are different in regards to verbal and spatial abilities, opposing views suggest the differences are less significant than earlier studies suggested. In addition, it has been proposed that verbal and spatial capacity can be enhanced with training and practice. Based on this premise, it would be plausible to suggest that the lack of significant findings based on the level of performance between gender and instructional method could be attributed to the “visual” nature of the degree programs from which the participants were selected. Of the 80 participants, 41 were in the Technical Illustration major and of those 41, 29 were female. A description of the program from the 1996-98 undergraduate catalog describes the major as a...”unique applied design program that integrates the excitement of design and illustration with the knowledge and control of graphic technology as preparation for an array of careers in business and industry” (p. 185). Therefore, it is plausible to suggest that the female students in the Technical Illustration major either entered the program with pre-existing spatial skills or as a result of the program, have developed and improved their spatial abilities to a higher degree through practice and training.

Failure to find significant differences in the level of performance for those participants receiving either the audio-only or video-only treatment could be attributed to the level of experience with similar performance tasks. Research suggests that a high level of experience increases one’s capacity to form mental images. Based on the hands-on nature of the majors represented by participants, it is plausible to suggest that the participants had a high level of experience with similar psychomotor tasks involving the tools and materials. As such, one could suggest that those participants receiving the audio-only or the video-only treatment had the capacity to associate the instructions with previous experience and establish referential connections to form consistent mental images of the instruction.

Survey questions were used to gather information relating to participants' use of computers and computer-based instruction in their school and work environments. Information relating to the clarity and satisfaction of the instructional methods was also gathered. Female participants indicated that they use computers more often in their school and work environment than male participants (Question One). Male participants indicated that they use computer-based instruction more than females (Question Two) and if available, would opt to use CBI to a higher degree (Question Three).

Analysis of survey response means provided a more detailed picture of differences within treatments. Within the audio-only treatment, males indicated higher use of CBI than females (Question Two) and indicated that the instructions were more useful (Question Five). Within the audio/video treatment, females responded significantly higher when questioned about their willingness to use CBI if available (Question Three).

Overall, the male participants expressed a higher level of satisfaction, than females, with the computer-based instruction based on survey results from Questions Four, Five, and Six. In addition, male responses indicated more experience with computers and expressed a higher level of satisfaction with the CBI. but means scores from Tests One and Two indicated females had a higher level of performance (Appendix Q). While at first glance these findings appear to suggest that the level of performance resulting from CBI may not be dependent on the level of satisfaction with the instruction, it should be noted that the variable of major was not controlled and the number of females and males in the Technical Illustration major was 29 and 12 respectively.

While it was the intent of the researcher to design a study with sound methodology and consistent protocol that improved upon earlier attempts, some limitations were identified which could affect the outcomes of this study and focus on the presentation platform for the instruction.

The presentation of instruction was performed using a Macintosh 540c Powerbook laptop computer. A laptop computer was chosen due to the mobility of the machine which lends itself to the dynamic structure of the technology classroom. The trade-off for this flexibility, compared to a desk top computer, involves the resolution and presentation capabilities for audio and video. While software was used to enhance the performance of the computer and to optimize the hard drive, the limitations of the laptop were, at times, exceeded.

The raw footage for the video was captured using a Hi8 videotape format. This allowed for high quality consumer footage. The next level of video quality would be a professional format such as 3/4” or digital. Due to cost constraints, it was necessary to forego the professional format and capture the footage using a consumer video format. Anticipating the limitations of the laptop presentation platform for video, an attempt was made to limit gross movement within the video frame. In addition, realizing that the video window within the instruction was limited in size, an attempt was made to focus the attention of the participant by using Close-Up and Extreme Close-Up framing of video footage in order to fill the viewing frame with the image and to limit the complexity of the subject within the video frame.

By focusing on the actual tasks or elements of assembly and not including irrelevant visual aspects of the work table for example, was, in part, a response to assist the learner in focusing on the relevant information without needing to search extensively for appropriate visual cues. Even though precautions were taken to provide an appropriate level of quality in regards to the video footage, detail suffered at times.

Audio was captured using a standard Macintosh microphone and edited using Sound Edit software. Again, the limitations of the presentation platform were at times exceeded. The integrity of the audio, for the audio-only treatment, was compromised and would intermittently skip. An analysis of the data pertaining to Total Reviews and Total Time for the instruction did not indicate a significant increase in either category for the audio-only treatment (Appendix O).

Learner control within computer-based instruction, is another variable inherent in the use of the instructional method. Research findings supporting both a high degree of learner control and a high degree of programmed control are available. A linear programming approach was selected for this study due to the structure or characteristics of the performance task. The task required the completion of specific steps in a specific order. In addition, the linear approach was selected based on research findings that indicate that allowing a learner to chose their navigation path within instruction tends to result in the learner making incorrect decisions. Although a nonlinear approach was not appropriate for the structured presentation of the performance task, it may have contributed value in the form of a review option for the participants. Allowing a participant to review the entire process before beginning, or to review previous steps may contribute to performance. While the nonlinear approach appears to have value, addressing the potential disadvantages, such as the learner selecting an incorrect navigation path throughout the instruction, would require a more comprehensive instructional program, thus increasing research and development time, as well as cost, for the instruction.

Addressing the value of CBI in regards to effectiveness and economy, one must identify and review the specific requirements of the instruction. The cost in time and resources for developing audio/video CBI is greater than the cost for developing verbal-only or visual-only presentation. If a performance task has psychomotor learning objectives that rely on factual information only, a verbal-only presentation may be most appropriate. If the performance objectives require the transfer of spatial information, a visual-only presentation may suffice. The question for educators and media developers that requires attention, focuses on the objectives for the performance task. Namely, does the task require application of factual information, spatial information, or a combination of both?

The Fitts-Posner (1967) model for classifying psychomotor skills suggests that skills are obtained in three stages that progress from cognitive, associative, to autonomous. If one would expect a learner to correctly perform a psychomotor task, then one would expect the learner to progress through a cognitive understanding of the process to an intermediate stage of being able to associate the cognitive information with the performance requirements and then to the final stage of autonomous application. The first or cognitive phase of skill attainment focuses on the factual information required; therefore, an instructional method that was primarily verbal in nature may be sufficient. A learner in the intermediate phase of skill attainment begins to associate the cognitive knowledge with the performance required, and in this phase, instruction that combines visual and verbal information may be more appropriate. In the final stage, the learner begins to develop proficiency with the performance, and may benefit from the use of instruction that is primarily visual in nature thus allowing the learner to observe and then practice correct behavior.

The nature of a performance task would typically require both factual and spatial objectives. Therefore, it would be plausible to suggest that a visual/verbal format of instruction would present information in a more appropriate manner. The potential for effective CBI for psychomotor performance objectives lies in identifying the nature of the content in regards to factual or spatial content and then employing the appropriate instructional methods for presentation of those objectives.

In retrospect, with related research suggesting that performance differences in regards to gender and instructional method exist, it was somewhat of a surprise not to find similar differences as part of this study. The performance task (Gepe Mount slide) may be the source of some contention--to simple to adequately discriminate psychomotor performance--although, based on the pilot study, it appeared to be complex enough in nature to provide adequate discrimination between treatments. However, after examining the specific evaluation criteria used to measure performance, it was found that only two of the five criteria affected performance. Quite possibly the performance task was too simplistic, particularly given academic experience and career orientation of the study participants, even though data suggested performance differences in two technical areas. A further analysis of those criterion measures that affected performance may provide insight into the factual or spatial nature of the task that influenced performance.

Recommendations for Further Study

Throughout the study, questions arose concerning the variables of learning task type, individual learner traits, and instructional methods which provided the focus for recommendations for additional investigation. Recommendations for further research include investigation in the following areas: different types of performance tasks; a more diverse population of participants; and an investigation of different instructional methods focusing on psychomotor objectives.

1. The development of a study which involves a different performance task. What results would be obtained by using a performance task that is more complex in nature and requires both factual and spatial objectives?

2. Use a more diverse sample in regards to major, program of study, or area of specialization. Is there a greater difference in performance between gender if participants are from majors that do not require a high level of visual and spatial aptitudes?

3. An investigation of the presentation of psychomotor content through the use of audio/video and animation. Will there be major differences in the level of performance resulting from participants receiving audio/video versus animated computer-based instruction?

4) An investigation of the relationship between participants' level of satisfaction with the instructional methods and their level of performance. For example, how does a high degree of

satisfaction with an instructional method correlate with their level of performance?

Conclusions

This study investigated the efficacy of computer-based instructional methods to teach psychomotor content. The performance task was selected, in part, due to its perceived high degree of difficulty or complexity required for completion and its application to the field of graphic design. Results indicate that a combined visual/verbal instructional format can increase psychomotor learning outcomes.

Research investigating visual and verbal instructional methods suggest that instruction which utilizes a visual/verbal combined method can increase performance and retention. The findings from this study were consistent with earlier research in regards to immediate performance, but inconsistent in regards to retention. In addition, literature suggested there are specific differences in regards to verbal and spatial abilities between males and females. However, this study failed to find significant gender differences in performance. Failure to find gender related performance differences could possibly be attributed to the level of simplicity of the psychomotor task or to the experience of the participants with similar tasks.

In regards to retention, the difference in scores for psychomotor tasks which were a part of Tests One and Two indicated the most notable change in scores occurred within the control group. The total mean score for all participants for Tests One and Two was 17.65 and 20.20 respectively. The 2.55 point or 6% increase in the Test Two score may be attributed to the phenomenon known as the Zeigarnik effect, which suggests that participants in the control group who are not given or provided, adequate information required for task completion, inquisitively seek out the information on their own.

Based on the results of this study and an analysis of the related research, it is apparent that the use of CBI in the teaching of psychomotor performance tasks can be beneficial. While economic and time considerations need to be considered when deciding on its appropriateness, one may also wish to consider that students found the CBI method to be more appealing and more apt to select it as a teaching method of choice.

This study supports the appropriateness of variables identified by Clark and Surgue (1989) identified to be used by educators and media developers when selecting or developing instructional applications. Namely, that one should identify and address the specific content and task type (appropriateness for CBI and complexity), learner attributes (aptitudes, interests, and experience), and the instructional method selected (economy of choice and efficacy).

CBI has the advantage of presenting technical or psychomotor substantive content in a redundant or congruent manner, while incorporating multiple instructional media and approaches, and provides an opportunity for increased learning and performance by learners. Also, the use of CBI formats to present psychomotor content to learners who have considerable experience with visual and spatial tasks in classroom settings, seems to have similar beneficial outcomes regardless of gender.

In addition to increasing the level of performance of learning outcomes, audio/video CBI appears to have been received more favorably by the learners over the audio-only and video-only CBI. Educators and media developers addressing the variables of task type, learner, and instructional method will be in a better position to select and develop CBI that is appropriate for attainment of desired learning outcomes.

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Appendix A

Visual/Verbal Media Script

Shot	Video	Audio	Shot Time	Total Time
1	90˚ CUT TO MS OF HAND SHOWING BOTH SIDES OF GEPE MOUNT TOGETHER BEFORE TAKING APART AND PLACING GRAY HALF ON TABLE METAL SIDE UP. CUT	Take the Gepe mount apart and place the gray half on a flat surface metal side up	00:10	00:10
2	135˚ CUT TO CU OF HAND HOLDING KODALITH WINDOW TO DETERMINE EMULSION SIDE. CUT	The next step is to identify the emulsion side of the Kodalith slide.	00:5	00:15
3	135˚ CUT TO ECU OF KODALITH SLIDE WINDOW SHOWING WRONG READING.	You can identify the emulsion side of the Kodalith slide three ways. 1) If there is text on the slide, it will be wrong reading.	00:10	00:25
4	135˚ CUT TO ECU OF KODALITH SLIDE WINDOW SHOWING DULLNESS.	2) Look for the side with the dull appearance.	00:05	00:30
5	135˚ CUT TO ECU OF KODALITH SLIDE WINDOW SHOWING CURVE OF FILM	3) Look for the side the film curls toward.	00:05	00:35
6	45˚ CUT TO CU OF HANDS PUTTING KODALITH SLIDE WINDOW INTO SLOTS ON METAL OF GEPE	After you have identified the emulsion side, insert the Kodalith slide window into the Gepe mount. Place the slide under the metal slots on the inside	00:15	00:50

		of the gray half of the mount. Ensure that the emulsion is toward the glass of the Gepe mount.		
7	90˚ CUT TO MS OF HAND APPLYING TAPE TO SECURE KODALITH SLIDE WINDOW	Being careful not to obscure the glass image area of the Gepe or the Kodalith slide mask, secure the mask with a small piece of scotch tape.	00:10	01:00
8	135˚ CUT TO MS OF HAND PICKING UP TRANSPARENCY	Place the gray half of the Gepe mount on a flat surface with the glass facing up. Position the film transparency over the Kodalith window, emulsion side up.	00:10	01:10
9	135˚ CUT TO ECU OF THE TRANSPARENCY SHOWING WRONG READING.	You can identify the emulsion side of the transparency three ways. 1) If there is text on the slide, it will be wrong reading.	00:10	01:20
10	135˚ CUT TO ECU OF THE TRANSPARENCY SHOWING DULLNESS.	2) Look for the side with the dull appearance.	00:05	01:25
11	135˚ CUT TO ECU OF THE TRANSPARENCY SHOWING CURVE OF FILM	3) Look for the side the film curls toward.	00:05	01:30
12	90˚ CUT TO CU OF HAND PLACING TRANSPARENCY OVER WINDOW EMULSION SIDE UP	After identifying the emulsion side, place the transparency on top of the glass aligning the edge of the transparency image with the edge of the Kodalith slide window.	00:10	01:40
13	45˚ CUT TO CU OF	Scratch the emulsion of	00:15	01:55

	HAND SCRATCHING EMULSIONS	the transparency with the Xacto knife so that the marks are on the outside of the Kodalith window. Mark both sides and the top and bottom of the film transparency.		
14	90˚ CUT OT MS OF HAND PLACING RULER ON TRANSPARENCY AND SCORING FILM ON FOUR SIDES	Using the ruler as a straight edge score the film transparency using the previous marks as guides. Apply only enough pressure to scratch the emulsion without cutting through the film.	00:10	02:05
15	45˚ CUT TO CU OF HAND BENDING TRANSPARENCY UNTIL IT SEPARATES--SHOW FOUR PIECES BEING REMOVED	Carefully fold and bend the transparency on the scored lines and break off excess portions of transparency film.	00:20	02:25
16	90˚ CUT TO CU OF TRANSPARENCY BEING ALIGNED ON KODALITH MASK AND BEING TAPED TO KODALITH MASK	Align the slide transparency on the Kodalith mask and secure with a small piece of scotch tape on both the top and bottom.	00:15	02:40
17	135˚ CU OF HAND TURNING THE SLIDE OVER TO LOOK THROUGH GEPE WINDOW FOR OBSTRUCTION	Visually check the Gepe slide window for tape obstructions and carefully remove if present. Retape if necessary.	00:10	02:50
18	45˚ MS OF HAND TURING OVER SLIDE FOR INSPECTION AND	Visually inspect the slide for dust or other foreign material and remove any	00:10	03:00

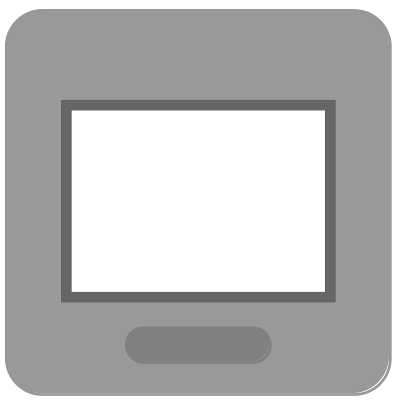
	USING CAN OF COMPRESSED AIR TO CAREFULLY REMOVE DUST FROM SLIDE	excess dust with the can of compressed air.		
19	90˚ MS OF HAND SNAPPING BOTH HALVES OF GEPE MOUNT TOGETHER	Affix the white half of the Gepe mount to the gray half and snap together. You will be able to both hear and feel the components snap together.	00:10	03:10
20	135˚ MS OF HAND TURNING SLIDE AROUND FOR INSPECTION	Visually check for alignment and make necessary corrections.	00:10	03:20
21	90˚ MS OF HAND LABELING SLIDE ON TOP PORTION OF THE GRAY HALF OF THE GEPE MOUNT	Label the slide with your 4 digit identification number by writing your number on the top portion of the gray half of the slide with the image upside-down.	00:10	03:30

Appendix B

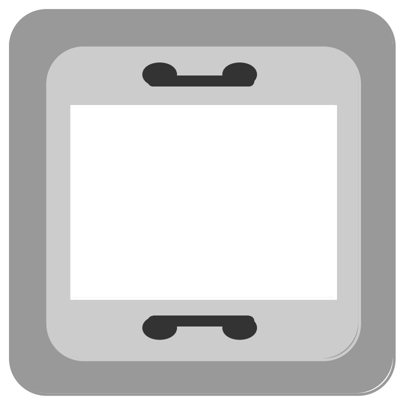
Introduction to Learning Task

Welcome to the Gepe Mount Manipulated Slide presentation. For this task you will be provided instructions describing the correct procedure for assembling a manipulated slide using the Gepe mount system. In order to assist you in completing the task the following pictorial representation of the components and required tools are provided. Feel free to ask questions.

Gepe mount

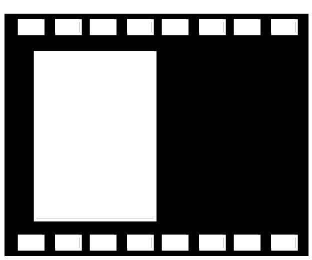


Gray Half-Outside



Gray Half-Inside

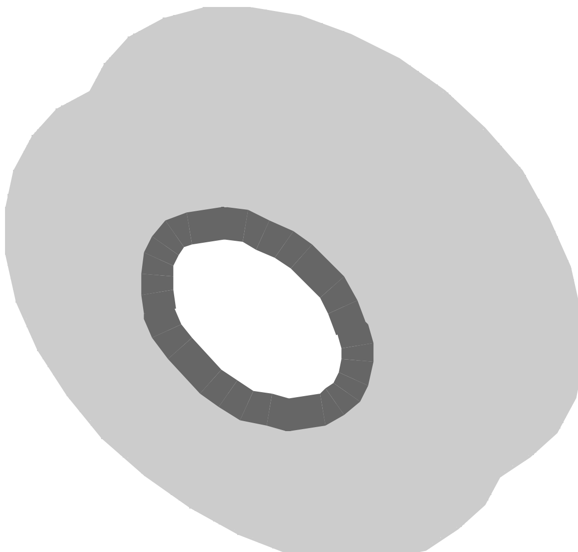
Kodalith Slide Mask Transparency



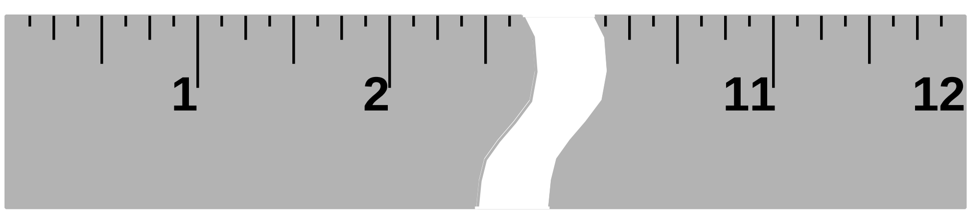
35mm Slide

Xacto Knife

Scotch Tape



Straight edge.



Evaluation of the finished slide will be based on the following criteria:

Labeling-The slide must be labeled with the participant ID# in the correct location.

Cycle Ability-The slide must successfully cycle from the slide tray to the projector and back to slide tray.

Clearness of Image Area-The image area (glass windows, film transparency, and Kodalith slide mask) must be free of scratches, tape, and fingerprints that will impede image projection. In addition, the Kodalith mask must be under the clips of the Gepe Mount and both the transparency and the mask must be secured with tape.

Emulsion To Light Source-The emulsion of the slide transparency and the Kodalith slide mask must be secured in the Gepe mount so that the emulsion side will be toward the light source.

Image Arrangement-The slide transparency must be arranged in the Kodalith slide window in a manner such that the edge of the slide transparency is square with the edge of the Kodalith slide window.

Appendix C

Script Review Request

You are being asked to review a media script that will be used to develop media used in a study comparing the effects of various instructional methods which incorporate Computer Based Instruction (CBI) on the psychomotor performance of college students. Your review comments will guide me in improving the script for media production. Information provided that may be of some value for your review includes: Performance Task Procedures, Evaluation Criteria, Media Script and an Evaluation Comments Form.

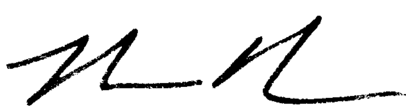
You have been selected due to your expertise in the area of video production. Based on this experience you are asked to review the media script for technical and procedural content, clarity, accuracy, and readability.

The audience for this media will consist of college students enrolled in Visual Communication Technology 203, an introductory technology course within the College of Technology at Bowling Green State University.

The subjects participating in the study will receive an introduction to the performance task which includes a description of the task, tools and materials identification, and evaluation criteria. After the introduction the subjects will receive the media and following the media the subjects will perform the psychomotor task.

If you have any questions regarding this information please feel free to contact Mitch Henke at 231-5866 or email at henkem@vt.edu.

Thank you for providing your invaluable assistance in this review.



Mitchell E. Henke
Graduate Student, EDVT

Performance Task Procedures

1) Place gray half of Gepe mount on a flat surface metal side up

2) Affix Kodalith onto gray half of mount, emulsion side up
- emulsion side is dull or wrong reading side
- align Kodalith into slots on metal portion of Gepe
- secure with small piece of scotch tape
- do not obscure image area with tape

3) Position transparency over the Kodalith window, emulsion side up
- emulsion side is dull, wrong reading, and curls towards emulsion

4) Make marks for cutting by scratching the film's emulsion with Xacto knife blade

5) Use a straight edge and Xacto knife to score the emulsion side of the transparency where cut is desired (do not cut through transparency)

6) Fold/bend transparency on the scored line and break off excess portion of transparency film

7) Align transparency on mask and secure with scotch tape

8) Remove any excess dust

9) Affix white half of Gepe mount to gray half, snap into place

10) Visually check for alignment and make necessary corrections

11) Label slide and place into slide tray, gray side facing you and upside down

Evaluation Criteria

Labeling	The slide must be labeled on the correct side and in the correct orientation.	Scored with a 10 or a 0.
Cycle Ability	The slide must successfully cycle from the slide tray to the projector.	Scored with a 10 or a 0.
Clearness of Image Area	The image area (glass windows, film transparency, and Kodalith slide mask) must be free of dust, scratches, tape, and fingerprints that will impede projection.	Scored 10-0 with a point deduction for each occurrence of dust, scratches, tape, or fingerprints.
Emulsion To Light Source	The emulsion of the slide transparency and the Kodalith slide mask must be secured in the Gepe mount so that the emulsion side will be toward the light source.	Scored 10, 5, or 0 with 5 points given for correct orientation of the slide transparency and the Kodalith slide mask.
Image Arrangement	The slide transparency must be arranged in the Kodalith slide window in a manner such that the edge of the slide transparency is square with the edge of the Kodalith slide window.	Score 10 or 0 based on the alignment of the film edges.

Media Script

Audio	Time	Video
Take the Gepe mount apart and place the gray half on a flat surface metal side up	10	ECU OF HAND SHOWING BOTH SIDES OF GEPE MOUNT TOGETHER BEFORE TAKING APART AND PLACING GRAY HALF ON TABLE METAL SIDE UP
The next step is to insert the Kodalith slide window into the slots on the inside of the gray half of the Gepe mount with the emulsion toward the glass of the Gepe mount. You can identify the emulsion side of the Kodalith slide three ways. -Look for wrong reading side -The side with the dull appearance -The side the film curls toward	35	ECU OF KODALITH SLIDE WINDOW SHOWING WRONG READING, DULLNESS, AND CURVE OF FILM
After you have identified the emulsion side insert the Kodalith slide window into slots on the inside of the gray half of Gepe mount with the emulsion toward the glass of the Gepe mount. Being careful not to obscure the glass image area of the Gepe or the Kodalith slide mask, secure the mask with small piece of scotch tape.	35	ECU OF HANDS PUTTING KODALITH SLIDE WINDOW INTO SLOTS ON METAL OF GEPE ZOOM CU OF HAND APPLYING TAPE TO SECURE KODALITH SLIDE WINDOW
With the gray half of the Gepe mount facing up on a flat surface position film transparency over the Kodalith window, emulsion side up.	25	MS OF HAND PICKING UP TRANSPARENCY

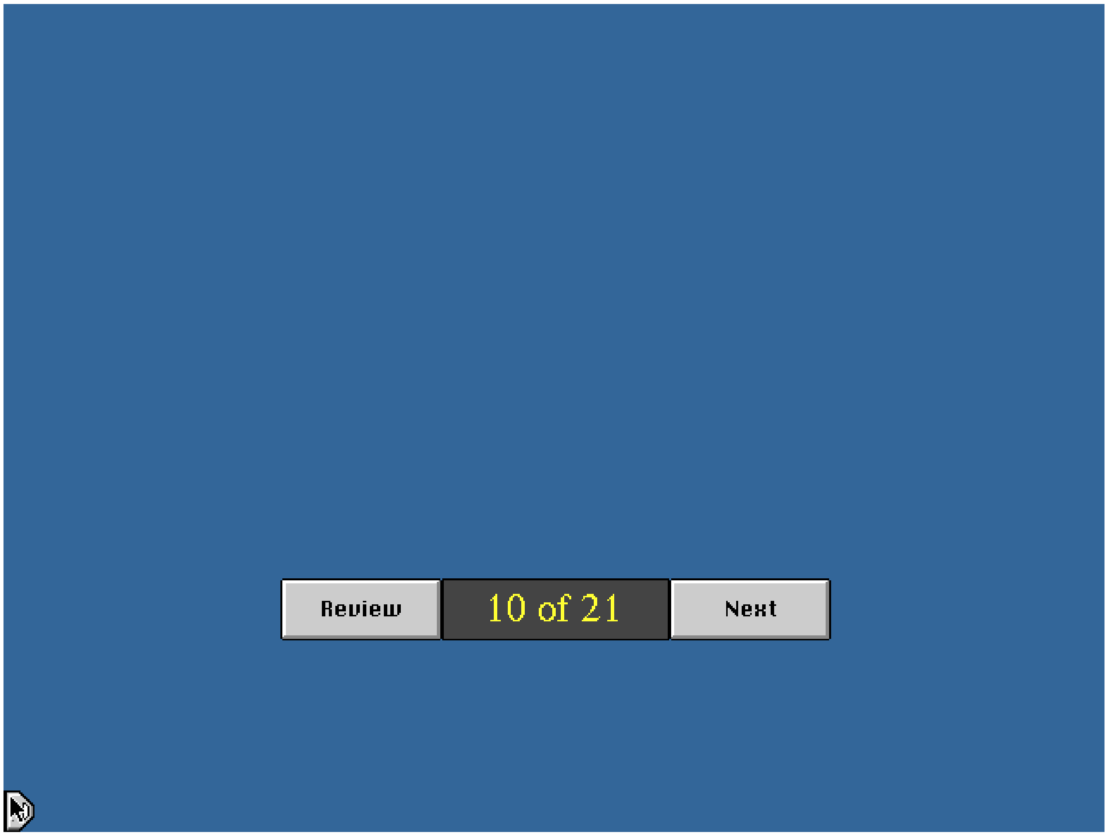
The emulsion side is the wrong reading side, the side with the dull appearance, and the side the film curls toward.		ZOOM TO ECU OF KODALITH SLIDE WINDOW SHOWING WRONG READING, DULLNESS, AND CURVE OF FILM
Visually ensure that the edge of the film transparency is aligned with the edges of the Kodalith slide window before making marks for cutting. Make cutting marks by scratching the film's emulsion with Xacto knife blade	25	CU OF HANDS PLACING TRANSPARENCY OVER WINDOW IN KODALITH SLIDE ON GEPE ON TOP OF TABLE ECU OF HAND SCRATCHING EMULSION OF FILM TRANSPARENCY WITH XACTO KNIFE
After marking the slide transparency, use a straight edge and Xacto knife to score the emulsion side of the transparency where cut is desired. Do not try to cut through transparency.	20	CU OF STRAIGHT EDGE ON TRANSPARENCY AND SHOW SCRIBING WITH XACTO KNIFE
Carefully fold and bend the transparency on the scored lines and break off excess portions of transparency film. Be careful not to touch image area with fingers.	20	CU OF HAND BENDING TRANSPARENCY UNTIL IT SEPARATES
Align the slide transparency on the Kodalith mask and secure with a small piece of scotch tape on both the top and bottom.	15	CU OF TRANSPARENCY BEING ALIGNED ON KODALITH MASK AND BEING TAPED TO KODALITH MASK
Visually check the Gepe slide window for tape obstructions and carefully remove if present.	10	CU OF HAND TURNING THE SLIDE OVER TO LOOK THROUGH GEPE WINDOW FOR

Retape if necessary.		OBSTRUCTION
Visually inspect the slide for dust or other foreign material and remove any excess dust with the canned air.	10	CU OF HAND TURING OVER SLIDE FOR INSPECTION ZOO TO MS OF HAND USING CAN OF COMPRESSED AIR TO CAREFULLY REMOVE DUST FROM SLIDE
Affix the white half of the Gepe mount to the gray half and snap into together. You will be able to both hear and feel the components snap together.	15	MS OF HAND SNAPPING BOTH HALVES OF GEPE MOUNT TOGETHER
Visually check for alignment and make necessary corrections. Make any necessary corrections.	10	MS OF HAND TURNING SLIDE AROUND FOR INSPECTION
Label the slide with your 4 digit identification number by writing your number on the top portion of the gray half of the slide.	10	MS OF HAND LABELING SLIDE ON TOP PORTION OF THE GRAY HALF OF THE GEPE MOUNT
Place into slide tray, gray side facing you and with the image upside down.	10	MS OF HAND PLACING SLIDE IN SLIDE TRAY
		FADE TO BLACK

Evaluation Comments

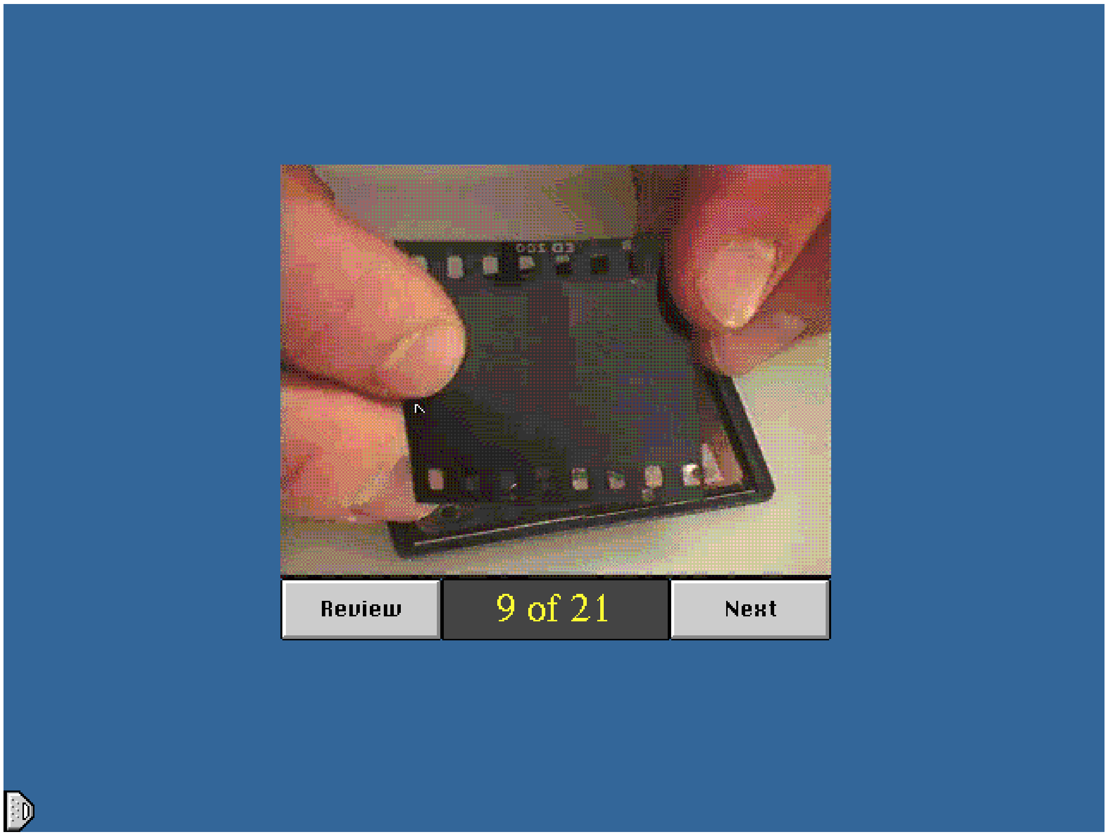
Appendix D

Window Layout for Audio-Only Treatment



Appendix E

Window Layout for Video-Only and Audio/VideoTreatment



Appendix F

Gepe Mount Task Required Psychomotor Abilities and Physical Proficiency Abilities Based on Fleishman.

1) Place gray half of Gepe mount on a flat surface metal side up

Psychomotor Abilities: multilimb coordination, response orientation, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

2) Affix Kodalith onto gray half of mount, emulsion side up

- *emulsion side is dull or wrong reading side*
- *align Kodalith into slots on metal portion of Gepe*
- *secure with small piece of scotch tape*
- *do not obscure image area with tape*

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

3) Position transparency over the Kodalith window, emulsion side up

- *emulsion side is dull, wrong reading, and curls towards emulsion*

Psychomotor Abilities: control precision, multilimb coordination, response orientation, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

4) Make marks for cutting by scratching the film's emulsion with Xacto knife blade

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

5) Use a straight edge and Xacto knife to score the emulsion side of the transparency where cut is desired (do not cut through transparency)

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

6) Fold/bend transparency on the scored line and break off excess portion of transparency film

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

7) Align transparency on mask and secure with scotch tape

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

8) Remove any excess dust

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

9) Affix white half of Gepe mount to gray half, snap into place

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

10) Visually check for alignment and make necessary corrections

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

11) Label slide an place into slide tray, gray side facing you and upside down

Psychomotor Abilities: control precision, multilimb coordination, response orientation, rate of control, manual dexterity, finger dexterity, arm-hand steadiness, aiming

Physical Proficiency Abilities: static strength

Appendix G

Gepe Mount Task Requirements and Corresponding Level of Performance Based on Simpson's Schema.

1) Place gray half of Gepe mount on a flat surface metal side up

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.12 Visual--seeing
  - 1.13 Tactile--touching
- 1.20 Cue Selection--differentiating proper cue as a guide
- 1.30 Translation--determining the meaning of a cue for action

2.0 Set--readiness for action
- 2.1 Mental Set--knowledge necessary to enable action
- 2.2 Physical Set--focusing of attention and body position
- 2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision
- 3.1 Imitation--copying an observed performance of another

2) Affix Kodalith onto gray half of mount, emulsion side up
- *emulsion side is dull or wrong reading side*
- *align Kodalith into slots on metal portion of Gepe*
- *secure with small piece of scotch tape*
- *do not obscure image area with tape*

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.12 Visual--seeing
  - 1.13 Tactile--touching
- 1.20 Cue Selection--differentiating proper cue as a guide
- 1.30 Translation--determining the meaning of a cue for action

2.0 Set--readiness for action
- 2.1 Mental Set--knowledge necessary to enable action
- 2.2 Physical Set--focusing of attention and body position
- 2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision

3.1 Imitation--copying an observed performance of another

3) Position transparency over the Kodalith window, emulsion side up
- emulsion side is dull, wrong reading, and curls towards emulsion

1.0 Perception--parallel to receiving in the affective domain
1.10 Sensory
1.12 Visual--seeing
1.13 Tactile--touching
1.20 Cue Selection--differentiating proper cue as a guide
1.30 Translation--determining the meaning of a cue for action
2.0 Set--readiness for action
2.1 Mental Set--knowledge necessary to enable action
2.2 Physical Set--focusing of attention and body position
2.3 Emotional Set--favorable attitude
3.0 Guided Response--overt act under supervision
3.1 Imitation--copying an observed performance of another

4) Make marks for cutting by scratching the film's emulsion with Xacto knife blade

1.0 Perception--parallel to receiving in the affective domain
1.10 Sensory
1.12 Visual--seeing
1.13 Tactile--touching
1.20 Cue Selection--differentiating proper cue as a guide
1.30 Translation--determining the meaning of a cue for action
2.0 Set--readiness for action
2.1 Mental Set--knowledge necessary to enable action
2.2 Physical Set--focusing of attention and body position
2.3 Emotional Set--favorable attitude
3.0 Guided Response--overt act under supervision
3.1 Imitation--copying an observed performance of another

5) Use a straight edge and Xacto knife to score the emulsion side of the transparency where cut is desired (do not cut through transparency)

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.12 Visual--seeing
  - 1.13 Tactile--touching
- 1.20 Cue Selection--differentiating proper cue as a guide
- 1.30 Translation--determining the meaning of a cue for action

2.0 Set--readiness for action
- 2.1 Mental Set--knowledge necessary to enable action
- 2.2 Physical Set--focusing of attention and body position
- 2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision
- 3.1 Imitation--copying an observed performance of another

6) Fold/bend transparency on the scored line and break off excess portion of transparency film

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.11 Auditory--hearing
  - 1.12 Visual--seeing
  - 1.13 Tactile--touching
- 1.20 Cue Selection--differentiating proper cue as a guide
- 1.30 Translation--determining the meaning of a cue for action

2.0 Set--readiness for action
- 2.1 Mental Set--knowledge necessary to enable action
- 2.2 Physical Set--focusing of attention and body position
- 2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision
- 3.1 Imitation--copying an observed performance of another

7) Align transparency on mask and secure with scotch tape

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.12 Visual--seeing

1.13 Tactile--touching
1.20 Cue Selection--differentiating proper cue as a guide
1.30 Translation--determining the meaning of a cue for action
2.0 Set--readiness for action
2.1 Mental Set--knowledge necessary to enable action
2.2 Physical Set--focusing of attention and body position
2.3 Emotional Set--favorable attitude
3.0 Guided Response--overt act under supervision
3.1 Imitation--copying an observed performance of another

8) Remove any excess dust

1.0 Perception--parallel to receiving in the affective domain
1.10 Sensory
1.12 Visual--seeing
1.13 Tactile--touching
1.20 Cue Selection--differentiating proper cue as a guide
1.30 Translation--determining the meaning of a cue for action
2.0 Set--readiness for action
2.1 Mental Set--knowledge necessary to enable action
2.2 Physical Set--focusing of attention and body position
2.3 Emotional Set--favorable attitude
3.0 Guided Response--overt act under supervision
3.1 Imitation--copying an observed performance of another

9) Affix white half of Gepe mount to gray half, snap into place

1.0 Perception--parallel to receiving in the affective domain
1.10 Sensory
1.11 Auditory--hearing
1.12 Visual--seeing
1.13 Tactile--touching
1.20 Cue Selection--differentiating proper cue as a guide
1.30 Translation--determining the meaning of a cue for action
2.0 Set--readiness for action
2.1 Mental Set--knowledge necessary to enable action
2.2 Physical Set--focusing of attention and body position
2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision
- 3.1 Imitation--copying an observed performance of another

10) Visually check for alignment and make necessary corrections

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.12 Visual--seeing
  - 1.13 Tactile--touching
- 1.20 Cue Selection--differentiating proper cue as a guide
- 1.30 Translation--determining the meaning of a cue for action

2.0 Set--readiness for action
- 2.1 Mental Set--knowledge necessary to enable action
- 2.2 Physical Set--focusing of attention and body position
- 2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision
- 3.1 Imitation--copying an observed performance of another

11) Label slide and place into slide tray, gray side facing you and upside down

1.0 Perception--parallel to receiving in the affective domain
- 1.10 Sensory
  - 1.12 Visual--seeing
  - 1.13 Tactile--touching
- 1.20 Cue Selection--differentiating proper cue as a guide
- 1.30 Translation--determining the meaning of a cue for action

2.0 Set--readiness for action
- 2.1 Mental Set--knowledge necessary to enable action
- 2.2 Physical Set--focusing of attention and body position
- 2.3 Emotional Set--favorable attitude

3.0 Guided Response--overt act under supervision
- 3.1 Imitation--copying an observed performance of another

Appendix H

Virginia Polytechnic Institute and State University Participation Consent Form

Title of Project: An Investigation of the Instructional Efficacy of Visual and Verbal Instructional Methods of Computer-Based Instruction

Principle Investigator: Mitchell E. Henke

How Involved
The purpose of this study is to investigate the efficacy of visual and verbal instructional methods of Computer-Based Instruction. The results of this study will provide the researcher with information on instructional methods using Computer-Based Instruction.

This study involves:

1. Viewing instructional procedures for a psychomotor performance task
2. Performing the psychomotor instructional task

Privacy
Please record the last four digits of your Social Security number on all forms provided. This identification number will be used for the analysis of the research. ALL reports of the results will be based on group data. NO INDIVIDUAL SCORES WILL BE REPORTED

Benefits
Information resulting from this study will help guide educators and media developers in selecting and producing educational media.

Withdraw Process
As a subject in this study you are free to withdraw at any time without penalty or prejudice.

Contacts
This study has been approved by the Human Subjects Committee and the Institutional Review Board of Virginia Tech. If you have questions feel free to contact Mitchell E. Henke (218-755-9285), or Dr. James J. Buffer (540-231-8725).

Consent

I hereby agree to voluntarily participate in the research project described above and under the conditions described above.

ID# ____________ Signature ______________________________Date _______________

Appendix I

Gepe Mount Task Objectives

Upon completion of the Gepe mount activity the student will:

Identify tools and materials necessary to create a manipulated slide using a Gepe mount.

Gain practice in the correct application of the tools as required to complete a manipulated slide using a Gepe mount

Appendix K

Evaluation Form for Test One

_____________ ID#

_____________ Score #1

0	3	6	Labeling	
0		4	Cycle ability	
0 2 4 6 8 10 12 14 16 18 20			Clearness of Image area	___ scratch____tape ___ prints____ assembly
0	2	4	Emulsion to light source	
0	3	6	Image arrangement	

Evaluation of the finished slide will be based on the following criteria:

Labeling-The slide must be labeled with the participant ID# in the correct location.

Scored with a 3 for ID#, 3 for any text in correct location, or 6 for ID# in correct location.

Cycle Ability-The slide must successfully cycle from the slide tray to the projector and back to slide tray.

Scored with a 4 or a 0 with a 4 for a successful cycle from and back to the slide tray and 0 for an unsuccessful cycle.

Clearness of Image Area-The image area (glass windows, film transparency, and Kodalith slide mask) must be free of scratches, tape, and fingerprints that will impede image projection. In addition, the Kodalith mask must be under the clips of the Gepe Mount and both the transparency and the mask must be secured with tape.

Scored 20-0 with a 2 point deduction for each occurrence of scratches, tape, or fingerprints in image area, and a 2 point deduction for failure to place the mask under the clips of the Gepe Mount, for failure to secure the mask with tape, and failure to secure the transparency with tape.

Emulsion To Light Source-The emulsion of the slide transparency and the Kodalith slide mask must be secured in the Gepe mount so that the emulsion side will be toward the light source.

Scored 4, 2, or 0 with 2 points given for correct emulsion orientation of the slide transparency and 2 points for correct emulsion orientation of the Kodalith slide mask. Correct orientation is emulsion toward the gray half of the Gepe Mount.

Image Arrangement-The slide transparency must be arranged in the Kodalith slide window in a manner such that the edge of the slide transparency is square with the edge of the Kodalith slide window.

Scored with a 3 for image located in the left half of the slide when viewed from the gray half with the image right side up, 3 for image orientation such that the pillars in the image progress from left to right, or 6 for correct orientation and placement.

Appendix L

Evaluation Form for Test Two

_____________ ID#

_____________ Score #2

0	3	6	Labeling	
0		4	Cycle ability	
0 2 4 6 8 10 12 14 16 18 20			Clearness of Image area	___ scratch____tape ___ prints____ assembly
0	2	4	Emulsion to light source	
0	3	6	Image arrangement	

Evaluation of the finished slide will be based on the following criteria:

Labeling-The slide must be labeled with the participant ID# in the correct location.

Scored with a 3 for ID#, 3 for any text in correct location, or 6 for ID# in correct location.

Cycle Ability-The slide must successfully cycle from the slide tray to the projector and back to slide tray.

Scored with a 4 or a 0 with a 4 for a successful cycle from and back to the slide tray and 0 for an unsuccessful cycle.

Clearness of Image Area-The image area (glass windows, film transparency, and Kodalith slide mask) must be free of scratches, tape, and fingerprints that will impede image projection. In addition, the Kodalith mask must be under the clips of the Gepe Mount and both the transparency and the mask must be secured with tape.

Scored 20-0 with a 2 point deduction for each occurrence of scratches, tape, or fingerprints in image area, and a 2 point deduction for failure to place the mask under the clips of the Gepe Mount, for failure to secure the mask with tape, and failure to secure the transparency with tape.

Emulsion To Light Source-The emulsion of the slide transparency and the Kodalith slide mask must be secured in the Gepe mount so that the emulsion side will be toward the light source.

Scored 4, 2, or 0 with 2 points given for correct emulsion orientation of the slide transparency and 2 points for correct emulsion orientation of the Kodalith slide mask. Correct orientation is emulsion toward the gray half of the Gepe Mount.

Image Arrangement-The slide transparency must be arranged in the Kodalith slide window in a manner such that the edge of the slide transparency is square with the edge of the Kodalith slide window.

Scored with a 3 for image located in the left half of the slide when viewed from the gray half with the image right side up, 3 for image orientation such that the pillars in the image progress from left to right, or 6 for correct orientation and placement.

Appendix M

Descriptive Statistics of Participants

Age	Male	Female	Total
Mean	22.48	21.80	22.14
Std. Dev.	4.52	4.23	4.37
Std. Error	.72	.67	.49
Minimum	18.00	18.00	18.00
Maximum	47.00	42.00	47.00
Variance	20.46	17.91	19.06
Range	29.00	24.00	29.00
Sum	899.00	872.00	1771.00
Median	21.50	20.50	21.00
Mode	21.00	20.000	20.00
Observations	**40**	**40**	**80**

Major Areas of Study Represented	Major	Male	Female	Total
Technical Illustration	TECI	12	29	41
Industrial Technology	ITEC	16	3	19
Industrial Technology Education	INTE	7	0	7
Undeclared	UND	2	3	5
Industrial Technology-Associate in Science	ITAS	1	0	1
Art Education	ARTE	0	1	1
Chemistry	CHEM	0	1	1
Business Administration	BUAD	0	1	1
Elementary Education	EEDU	0	1	1
Industrial Arts-Bachelor of Arts	IABA	0	1	1
Liberal Education	LBED	1	0	1
Pre-engineering	PREN	1	0	1
TOTAL		**40**	**40**	**80**

Appendix N

Participant Response to Post-Intervention Survey Questions

		Audio	Video	Audio/ Video	Total
Question 1	Male	3.20	3.30	3.00	3.17
	Female	2.80	3.60	3.30	3.23
	Total	**3.00**	**3.45**	**3.15**	**3.20**
Question 2	Male	1.70	1.30	1.60	1.53
	Female	1.10	1.10	1.70	1.30
	Total	**1.40**	**1.20**	**1.65**	**1.42**
Question 3	Male	2.00	2.50	2.70	2.17
	Female	1.60	2.00	2.70	2.10
	Total	**1.80**	**2.25**	**2.70**	**2.13**
Question 4	Male	2.70	2.80	3.10	2.87
	Female	2.20	2.60	3.00	2.60
	Total	**2.45**	**2.70**	**3.05**	**2.73**
Question 5	Male	2.80	3.00	3.20	3.00
	Female	2.00	2.70	3.00	2.57
	Total	**2.4**	**2.85**	**3.10**	**2.78**
Question 6	Male	2.20	2.50	2.60	2.43
	Female	2.10	2.20	2.50	2.27
	Total	**2.15**	**2.35**	**2.55**	**2.35**

Appendix O

Number of Reviews Within Instruction and Total Time for Completion in Seconds

		Number of Reviews	Total Time in Seconds for Completion
Male	Audio	6.40	594.03
	Video	11.30	660.03
	Audio/Video	7.30	702.90
	Control	-------	561.30
	Total	8.33	629.56
Female	Audio	8.10	682.05
	Video	11.80	599.92
	Audio/Video	7.00	573.79
	Control	-------	516.80
	Total	**8.97**	**593.14**

Appendix P

Days Between Tests One and Two

	Mean Days Between Tests	S.D.	Variance	N
Male	10.65	1.69	2.85	40
Audio	10.20	1.55	2.40	10
Video	11.00	1.15	1.33	10
Audio/Video	11.20	1.69	2.84	10
Control	10.20	2.20	4.84	10
Female	11.55	1.63	2.66	40
Audio	11.00	1.89	2.93	10
Video	12.40	1.71	2.93	10
Audio/Video	11.60	1.58	2.49	10
Control	11.20	1.34	1.29	10
Total	**11.10**	**1.71**	**2.93**	**80**

Appendix Q

Mean Scores for Tests One and Two by Treatment and Gender

	Mean Score Test One	Mean Score Test Two
Male	22.58	21.65
Audio	22.10	18.50
Video	22.80	21.40
Audio/Video	26.70	25.30
Control	18.70	21.40
Female	23.30	23.83
Audio	24.50	25.00
Video	24.80	24.80
Audio/Video	27.30	26.50
Control	16.60	19.00
Total	**22.94**	**22.74**

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Education:

Doctor of Philosophy, Technology Education, degree earned April, 1997. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Dissertation: The Effects of Three Methods of Computer-Based Instruction on Psychomotor Performance of College Students.

Master of Education, Career and Technology Education, August, 1991. Bowling Green State University, Bowling Green, Ohio. Concentration: Teaching/Training.

Bachelor of Science, Industrial Technology Education, December, 1989. The Ohio State University, Columbus, Ohio. Course work included engineering graphics, graphic arts, and material processing.

Experience:

Department of Industrial Technology, Bemidji State University, Bemidji, Minnesota. Assistant Professor. August, 1996 to present. • Develop and deliver instruction for courses dealing with photography, print, and visual presentation. Initiating the introduction
of computer-based processes related to visual communication.

Office of the University Provost, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Assistant to the Associate Provost. September, 1995 to August, 1996. • Assisted the Associate Provost with special projects relating to administrative duties. Projects included budget and presentation development and coordinating
university committees.

Center for Organizational & Technological Advancement (COTA), Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Graduate Assistant. May, 1994 to August, 1995. • Assisted the Director in developmental phases of a new center
designed to develop and deliver executive level training. Coordinated the design

and production of promotional pieces. Identified potential program areas and developed budgets and program materials.

Experience cont.:

Dean's Office, College of Education, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Graduate Assistant. August, 1992 to May, 1994. • Designed and prepared departmental and organizational informational pieces.

Office of the Economic Development and Assistance Center, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Research Associate. May, 1992 to August, 1992. • Assisted in the conception, development, and evaluation of an interactive multimedia self-employment assessment program.

College of Technology, Bowling Green State University, Bowling Green, Ohio. Instructor of Technology. August, 1991 to August, 1992. • Prepared and delivered instruction for courses dealing with photography, video, print, and visual presentation. Initiated the incorporation of digital applications in the photography and multimedia courses.

Center for Quality Management and Automation, Bowling Green State University, Bowling Green, Ohio. Technical Consultant. January, 1992 to August, 1992. • Produced and directed the production of visual media for public relations.

Governor's Summer Institute, Bowling Green State University, Bowling Green, Ohio. Instructor. 1990-1993. • Assisted in the development, coordination, and presentation of a week long visual communication program for gifted high school students.

CACUBO Management Institute, Milwaukee, Wisconsin. Marketing & Communication Consultant. 1989-present. • Design and manage the production of instructional and marketing materials such as offset and screen printed promotional items and multimedia slide/video presentations.

USA Design Workshop for Gifted Students, Bowling Green State University, Bowling Green, Ohio. Instructor. July, 1990.
• Developed and presented a 5 day creativity workshop for junior high students.

College of Technology, Bowling Green State University, Bowling Green, Ohio. Teaching Assistant. January, 1990 to August, 1991. • Taught courses dealing with photography, video, print, and visual presentation. Produced and directed a promotional video for the Visual Communication Technology program area.

College of Education, The Ohio State University, Columbus, Ohio. Designer and Screen Printer. August, 1988 to December, 1989.
• Managed the design and printing of promotional pieces using the
screen process method.

Presentations:

Presenter. *Basic Photography Skills*, Ohio Environmental Protection Agency, Bowling Green, Ohio, July 20, 1992.

Presenter. *Macintosh Multimedia*, Bowling Green Macintosh Users Group, Bowling Green State University, Bowling Green, Ohio, March
18, 1992.

Co-presenter. *Digital Halftone Preparation*, Midwest Screenprinters Association (MSPA), Bowling Green State University, Bowling
Green, Ohio, November 16, 1991.

Co-presenter. *Preparing an Effective Portfolio*, Society of Technical Communicators, Bowling Green State University, Bowling Green,
Ohio, November 4, 1991.

Presentation Chair. *What They Didn't Tell You About Your First Year of Teaching*, Ohio Technology Education Association Spring
Conference, Dayton, Ohio, March, 1991.

Co-presenter. *Investigating Technical Illustration*, Society of Technical Communicators, Bowling Green State University, Bowling Green, Ohio, March 2, 1991.

Presenter. *Desktop Design and Image Manipulation*, VCT Open
House, Bowling Green State University, Bowling Green, Ohio, October, 1990

Co-presenter. *Implementing Early Evaluation*, Graduate Student Professional Development, Bowling Green State University, Bowling Green, Ohio, August ,1990.

Publications:

Videotape. Produced and directed a video highlighting the Visual Communication Industry and the Visual Communication Technology
Major at Bowling Green State University, Bowling Green, Ohio, 1991.

Videotape. Produced and coordinated the production of a promotional videotape for the Center for Quality Management and Automation, Bowling Green State University, Bowling Green, Ohio, 1992.

Cover Illustrations. The Journal of Epsilon Pi Tau, Volume XVI, Number 1, Winter/Spring 1990, Number 2, Summer/Fall 1990, and Volume XVII, Number 1, Winter/Spring 1991.

<u>Activities:</u>

Member, Epsilon Pi Tau, International Honorary Fraternity, Alpha Chapter, The Ohio State University, Columbus, Ohio, 1989-present.

Past President, Epsilon Pi Tau, Alpha Gamma Chapter, 1990-91, Bowling Green State University, Bowling Green, Ohio.