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ABSTRACT

Both general and specific guidelines are proposed for the use of different types of graphics under specified conditions which would be relevant to various instructional applications of the videodisc. The general guidelines cut across several conditional variables--e.g., color, realism, motion--while the specific guidelines are directly related to the following 11 behavior categories: rule learning and using, classifying, identifying symbols, detecting, making decisions, recalling bodies of knowledge and using verbal information, performing gross motor skills, steering and guiding--continuous movement, recalling procedures--positioning movement, voice communicating, and attitude learning. Also included in this report are discussions of dynamic computer graphics; the relationship of graphics to learner characteristics; graphics and the videodisc, including integration of motion sequences and still frames, ability to slow or freeze action during demonstration of procedures, and different branching strategies; the ability of the intelligent videodisc to combine the advantages of the book, television, and computer-assisted instruction; changes which the videodisc will require in current methods of media selection; and implications of this study for further research. More than 50 references are listed. (CHC)

ISD FOR VIDEODISC TRAINING SYSTEMS

FIRST ANNUAL REPORT

VOL. III

GUIDELINES FOR EMPLOYING GRAPHICS IN A VIDEODISC TRAINING DELIVERY SYSTEM

July, 1979

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This is volume III of a three volume final report on "An Instructional Systems Development Model for Videodisc Training Delivery Systems with Interactive Capability." This volume presents guidelines for employing graphics in a videodisc training delivery system. First, general guidelines for employing graphics are presented. Graphics are discussed in terms of their use as signs, in terms of aesthetics, color, and motion. Two additional sections describe dynamic computer graphics and the relation of graphics to learner characteristics.

The second part of volume III contains specific guidelines for employing graphics in each of the eleven behavior categories described in TRADOC pamphlet 350-30 (IPISD). Both general and specific guidelines are summarized in job aid form for easy reference by instructional designers. The paper continues with a discussion of graphics and the videodisc, in which some of the graphics implications of this new technology are explored, including integration of motion sequences and still frames, ability to slow or freeze action during demonstration of procedures, and different branching strategies. The ability of the intelligent videodisc to combine the advantages of the book, television, and computer-ass[illegible] [illegible]struction is discu[illegible] [illegible] connection with the chang[illegible] [illegible]h the videodisc requ[illegible] [illegible]ur conception and method of media selection. The final section presents a number of research implications of the graphics study.

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The intr[illegible] the videodisc pla[illegible] possible the random ac[illegible] integrated motion sequ[illegible] still graphics. The purpose of this report is to propose some guidelines for employing several types of graphics under specified conditions which would be relevant to various instructional applications of the videodisc.

Several general and specific guidelines for employing graphics are presented in the report. The specific guidelines are

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) related to types of training objectives outlined in the Interservice Procedures for Instructional Systems Development (IPISD). The special role of graphics in relation to videodisc technology is also presented. Because of the current state-of-the-art, many of the guidelines presented in the report are necessarily only hypotheses and will require verification in future research studies. Several research issues are outlined in the report.

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GUIDELINES FOR EMPLOYING GRAPHICS IN A VIDEODISC TRAINING DELIVERY SYSTEM

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Summary

The introduction of the videodisc player will make possible the storage and random access display of graphic material and, to a lesser extent, motion sequences at far less cost than has previously been possible. By attaching a micro-computer to the videodisc player, sophisticated computer graphics may also be displayed. However, few empirically based principles or guidelines exist as to when, where, what kind, or how much instructional graphics should be used in training applications for this new medium.

The purpose of this report is to propose some guidelines, based on instructional design theory and published empirical findings, for the use of graphics under specified conditions. Because of the limited data available, many of the guidelines given are necessarily only hypotheses and require future verification.

To address the question, "What type of graphics should be used in various conditions?" it is first useful to identify and define different types of visual displays. The following categorization scheme is presented:

a. Alphanumerics
   1. Textual
   2. Tabular

b. Graphics

   1. Figural
   2. Symbolic
   3. Schematic
   4. Pictorial

c. Objects or Events

   1. Real Objects or Events
   2. Models, Mock-ups, or Simulators

General and specific guidelines for employing various types of graphics under different conditions are presented in this report. The general guidelines cut across several conditional variables while the specific guidelines are directly related to the types of training objectives outlined in the Interservice Procedures for Instructional Systems Development, TRADOC Pamphlet 350-30. The guidelines presented in the body of the report are summarized on the following pages.

General Guidelines

1. Graphics are not necessary and may actually be distracting if they are used as signs for concepts, objects or events with which the learner has had considerable previous experience. Under such conditions, the added external visual or graphic is redundant with the learner's mental visual image, and thus may not facilitate performance. Graphics become helpful and vital when the learner is exposed to new concepts, objects, or events for which he has no labels and/or corresponding visual images.

2. Pictures, color, realism, and motion generally increase the attraction and interest value of materials, are preferred by learners of all ages, and may significantly reduce attrition from training courses.

3. In general, color has little demonstrated effect on performance but may enhance learning when used to emphasize relevant cues and when actual color discrimination is required.

4. Motion generally has little effect on learning except when the information to be learned deals directly with motion or change. However, we hypothesize that realistic dramatic sequences may have considerable value in increasing interest, motivation, emotional impact, and in changing attitudes.

5. Interactive, dynamic, computer graphics offer a unique but largely unknown training application potential.

6. Complex, fixed pace, motion graphics may be beneficial for individuals of high mental ability but may deter learning for individuals of lower mental ability.

7. Simple line drawings, color or black and white, appear to be the most effective type of graphic for increasing achievement.

8. A learner control system which allows students to select that treatment which would be most appropriate for them at a given point of time may be more effective than assigning students with different abilities to a small number of alternate treatments.

Specific guidelines for various types of training objectives

1. Rule learning and using. The learning of complex procedural rules can be facilitated through the use of representations such as flow charts which graphically portray the order of the operations of the procedure and alternate paths which could be taken at decision points.

2. Classifying. Pictorial graphics should be used as examples of concepts which have concrete referents. In the initial stages of training, simplified pictorial graphics should be used in order to isolate and highlight critical attributes. Later stages of training could employ more realistic graphics in order to facilitate transfer to the real world environment or task.

3. Identifying symbols. Considerable drill and practice with corrective feedback using graphics of actual sumbols may be required in order to adequately learn how to identify symbols.

4. Detecting. The training of detecting behavior should involve the presentation of graphics within significant blocks of time and space which are realistic in terms of both the object itself and the natural noise of the environmental setting.

5. Making decisions. Training in decision making should involve instruction in the use and interpretation of various numerical relationships represented in both tabular displays and figural graphics.

6. Recalling bodies of knowledge and using verbal information. A graphical representation of the relationship between various facts and ideas can provide organization and meaning which may facilitate the storage and retrieval of verbal information. Pictures or line drawings inserted in textual, verbal information often have no effect on performance since they only illustrate concepts which coule have been readily visualized from the textual description.

7. Performing gross motor skills. The demonstration of a complex motor skill in real time may be too fast. However, slow motion could demonstrate the continuity of the movement while permitting critical aspects to be perceived. A videotape of a trainee's motor skill performance may be a very valuable feedback device.

8. Steering and guiding-continuous movement. Graphics used to present the relevant cues for steering and guiding behavior should have a high relationship to real world noise and time conditions in the later stages of training.

9. Recalling procedures, positioning movement. If the procedure to be learned involves the assembly or disassembly of a piece of equipment with many parts, then graphics would be necessary to show the various parts of the equipment and their relationship to each other.

10. Voice communicating. In general, graphics would not be necessary in the training of voice communicating behavior.

11. Attitude learning. Human modeling seems to be the most applicable, and probably the most effective approach for attitude learning. Attitude learning involves the imitation of a credible and respected human model's choices of action. A human model may be presented in several ways: appearing in person, in pictures, in movies or TV, or merely described as in a novel, history text, or biography.

Graphics and the Videodisc

The introduction of the new videodisc technology will make possible several strategies for employing graphics that heretofore have not been possible. One such strategy described in this report involves the use of the videodisc to demonstrate skills which involve continuous movement. Standard motion picture and television presentations are often ineffective because the real time motion is too fast for a trainee to see critical aspects of the movement and it is, at best, cumbersome to stop and repeat a sequence. The videodisc will eliminate these problems since a trainee will be able to adjust the speed of the motion sequence, stop on a single frame and look at the "frozen motion" for as long as desired, step through a series of frames one at a time, reverse the play and repeat the sequence (at any speed), stop a sequence to practice the movement, and then repeat the motion sequence for comparison with his own performance.

The availability of a powerful medium such as the videodisc with an attached microcomputer may enable more sophisticated objectives to be achieved by the student than were possible with less versatile media. In particular, powerful simulations may be developed and tailored to specific training goals.

Although the videodisc will make possible several innovative strategies for employing graphics, the videodisc will also be able to display most types of graphics which have become commonplace in other media. Therefore, all of the guidelines for employing graphics described in this paper should have direct application to the development of training materials for the new videodisc technology.

Research Implications

Although previous research on the effects of instructional graphics has provided guidance for the identification of principles for using graphics, many of the assumptions about the inherent value of graphics for instruction are still unsubstantiated. A partial list of research issues which need further investigation is presented in the body of this report.

Introduction[1]

The introduction of the videodisc player will make possible the storage and display of graphic material at far less cost than has previously been possible. It will allow for the integration and random access of motion sequences and specially prepared videopages (still frames) which contain graphics and/or textual material. With the attachment of a microcomputer to the player, computer graphics will also be available. The decreasing cost of microcomputers makes this application increasingly feasible. However, few principles or guidelines exist as to when, where, what kind, and how much graphics should be used in instructional applications of this new medium.

Educators and media specialists have extolled the virtues of visual aids and graphics for many years. Acceptance of the adage, "A picture is worth a thousand words," has led to the use of numerous forms of visual or graphic material in instruction: pictures, line drawings, schematics, graphs, charts, slides, film strips, motion pictures, television, etc. In a recent paper, Moore and Nawrocki (1978) described the historical arguments for using graphics and reviewed the research literature on the effects of instructional graphics. Their overall conclusion based on this review was that the assumptions about the inherent value of graphics for instruction are unsubstantiated by empirical research findings. However, they cite several studies which show that graphics can and do have a positive effect in certain specific instances.

The variable results obtained in the research findings reviewed by Moore and Nawrocki lead to the obvious conclusion that the appropriate question is not, "do graphics improve the effectiveness of instruction?", but rather, "what type of graphics, if any, will improve the effectiveness of instruction under different conditions?" Moore and Nawrocki suggest that three major classes of variables which relate to the effectiveness of graphics are 1) subject matter content, 2) task requirements, and 3) learner characteristics.

The purpose of this report is to propose some guidelines, based on instructional design theory and current empirical findings, for employing graphics under specified conditions. Because of the limited data available, many of the guidelines given are necessarily only hypotheses and require future verification.

[1]The authors would like to acknowledge the assistance of Dr. Joseph Lipson and Mike Hetzel in the preparation of this report. Mr. Hetzel helped identify reference material and example graphics while Dr. Lipson reviewed the entire report and offered many valuable suggestions. However, the authors accept full responsibility for the content of the report.

Types of Visual Displays

In order to address the question, "What graphics should be used under various conditions?" it is first necessary to identify and define different types of visual displays. The categorization scheme proposed here is based on the previous work of Moore and Nawrocki (1978), Tosti and Ball (1969), and Merrill, Towle, and Merrill (1975):

A. Alphanumerics
   1. Textual
   2. Tabular

B. Graphics
   1. Figural
   2. Symbolic
   3. Schematic
   4. Pictorial

C. Objects or Events
   1. Real objects of events
   2. Models, mock-ups, or simulators

<u>Alphanumerics</u>

This category basically includes the set of characters available on a standard typewriter keyboard. This category is subdivided to distinguish between textual and tabular displays, the physical distinction being primarily one of format. Although both of these can be generated on a standard typewriter, tabular displays are considerably more difficult to design and construct and are therefore generally more expensive to produce. Reading and understanding tabular displays may also require different abilities on the part of the trainee than reading and understanding textual information.

<u>Graphics</u>

This category basically includes all non-alphanumeric, two-dimensional displays and has been divided into four subcategories: figural, symbolic, schematic, and pictorial. This distinction between alpha-numeric and graphics displays may seem similar to the categories "digital" or "symbolic" (words and numbers) and "iconic" (pictures and diagrams) (Morris, 1938 and Knowlton, 1966). However, the authors agree with McDonald-Ross' (in press) assertion that too much is generally included under the iconic category. Thus, in the categorization scheme presented here the pictorial and schematic subcategories might be considered iconic, while the symbolic and figural subcategories would not be considered as either iconic or digital. The authors feel that these categories represent a better solution to the digital versus iconic problem than McDonald-Ross' (in press) classification according to purpose.

The pictorial and schematic subcategories include all two-dimensional representations of objects or events where the representation has some degree of resemblance or fidelity to the physical characteristics of the real object or event. The distinction between pictorial and schematic is basically one of degree of fidelity. Pictorial displays, which include photographs, paintings, drawings, etc., have greater fidelity than schematics, which include circuit diagrams, maps, blueprints, etc. Knowlton (1966) has suggested that the fidelity of a representation of an object or event can be thought of as having three "parts": the elements, their pattern of arrangement, and their order of connection. A graphic must have some fidelity in the elements in order to be classified as pictorial. On the other hand a schematic graphic would have the elements arbitrarily portrayed, while the pattern and/or order of connection would be isomorphic with the actual object or event. A highway road map would be classified as schematic since the elements (towns and cities) are generally represented by arbitrary geometric forms (circles and stars) while the pattern and order of connection of the cities and roads is isomorphic to the actual state of affairs.

The symbolic category refers to those graphic displays which have no resemblance or fidelity to actual objects but serve as arbitrary non-alphanumeric signs of the objects or events. Examples of symbolic graphics are a red cross, a trademark, an officer's insignia, etc.

The figural category includes graphic displays which are used to show relationships between abstract ideas and generally do not serve as signs for actual objects or events. Line graphs, pie charts, and histograms are examples of figural graphics.

The graphics displays described above could vary along additional dimensions such as still or motion (including animation); color, halftone, or black and white; degree of aesthetic value; degree of complexity or realism; and/or analogical reference (see section on Graphics as Signs). These dimensions could be thought of as sub-subcategories, each of which can vary within the four principle subcategories of figural, symbolic, schematic, and pictorial. The relevance of these additional dimensions will be addressed in appropriate sections in the remainder of this report.

Objects or Events

This category includes real-world objects and three-dimensional representations of objects such as models, mock-ups, or simulators. Real objects might include a flower, cow, truck, engine, building, rifle, mountain, etc. Events could include a session of the State Legislature, a football game, a supply raid, an enemy attack, etc. Models, mock-ups, and simulators would include a "Link Trainer," a styrofoam artillery shell, a plaster of Paris skeleton, a wooden tank, or a scale model battlefield.

General Guidelines for Employing Graphics

The employment of graphics does not automatically increase the effectiveness of instructional materials. The instructional usefulness of a specific graphic may lie somewhere on the following continuum:

Confusing — Distracting — Neutral — Helpful — Vital

Under certain conditions a given graphic might be confusing and have a negative effect on student achievement. Under other conditions a graphic might be vital for learning to occur. Under still other conditions the use of graphics may have neither positive nor negative effects on students performance.

The purpose of this report is to propose some guidelines for employing various types of graphics under different conditions. This section will present some general guidelines for employing graphics which cut across several different variables, while the following section will address more specific guidelines related to the Army's current taxonomy of training objectives.

Graphics as Signs

Many of the research studies on instructional graphics have found no significant differences in student achievement when instructional treatments which use graphics are compared with those which do not use graphics. There are probably many reasons for these non-significant differences. However, we would like to suggest that one of the major reasons graphics have a neutral effect is because they are used as signs (Knowlton, 1966) for objects or events with which the individual has had considerable previous experience. This previous experience can be recalled by the individual and used to create a mental visual image. Such a visual image can be triggered by symbols which, though arbitrary, have been previously learned as labels for the object or event. Under such conditions, the added external visual or graphic is redundant with the individual's mental visual image and thus does not improve learning.

Consider this idea from the perspective of concept learning. A concept is a class of objects, events, or symbols which are categorized together based on certain common characteristics. The entire class of objects is generally referred to by a common label. In order to learn a concept, the student usually should be exposed to a divergent set of instances of the concept. Under such conditions a concept label or word may be "worth a thousand pictures". Once a concept has been learned, then, using a picture as a sign for it is not only inefficient, it may also distract or interfere with the learners mental images. (However, if the picture is a divergent unencountered example, it may serve to further refine the learners "understanding" of the concept).

In considering the employment of graphics we should not overlook the significant power of word pictures. Great story tellers and novelists are able to capture the attention and imagination of their audiences by triggering mental images through the use of word descriptions. These word pictures may be more effective than actual pictures by directing attention to specific relevant details which would go unnoticed in a casual viewing of an actual picture.

Graphics become helpful and vital when the learner is exposed to new concepts, objects, or events for which he has no labels and/or corresponding visual images. However, even when the learner has had no previous experience with an object, he can often be taught various aspects of a new object through the use of verbal analogies where the new object is compared with or likened to a known object for which visual images are available in memory. Novelists and poets use analogies very effectively to increase the power of their word pictures in generating mental images. Analogies are especially valuable in teaching intangible or abstract concepts which are difficult to portray graphically. Knowlton (1966) has observed that a graphic may also be used as an analogical device. For example, Knowlton refers to a line drawing of a golfer hitting a golf ball which caroms off several trees lining the fairway. This picture is not used to represent a poor golf swing, but is used as an analogy to show how a golf ball is like an electron and a golf club is like a photon; and that a golfer hitting a golf ball caroming off trees is similar to what happens when a chlorophyll molecule is hit by a photon. However, care must be used when employing either verbal or graphic analogies since only certain aspects of one phenomena are analogous to another, while other aspects are not analogous.

<u>Aesthetics</u>

In our search for efficiency and effectiveness we should not overlook the role of aesthetics in life and in learning. Attraction, attention, interest, and motivation are all important aspects of learning. Students cannot learn unless they attend to the instructional materials. Hence, obtaining and maintaining attention is a necessary, although not sufficient, condition for learning to occur.

In general research (Levie and Dickie, 1973) has shown that pictures, color, realism, and motion increase the attraction and interest value of materials and are preferred by learners of all ages. Moore and Nawrocki report a study by Wali (1970) which showed that preference does significantly reduce student attrition. The creative talent of the artist or scriptwriter is another obvious factor which may affect the aesthetic value of a visual display.

Color

In general color has little effect on performance (Levie and Dickie, 1973; Kanner, 1968; Travers, 1967). However, color may enhance learning when used to emphasize relevant cues and to aid in making appropriate discriminations. Using color in this way is illustrated by instructional materials developed for the TICCIT Project (Bunderson, 1973; Mitre Corp., 1974). Color is also helpful if the task requires actual color discrimination (Travers, 1967). Color may also increase attention to emotional content (Scanlon, 1970). Future research on color variables should distinguish between three roles of color: 1) in attracting and maintaining attention and interest; 2) in directing attention to relevant cues; and 3) as a critical attribute of the subject matter itself (Fleming, 1979).

Motion

Motion generally has no effect on learning except when the information to be learned deals directly with motion or change (Levie and Dickie, 1973; Silverman, 1958; Allan and Weintraub, 1968). Guidelines on using motion are described in greater detail in later sections.

Special effects, optical effects, and music have not increased learning (Hoban & Van Orman, 1950). Dramatic sequences, comedy, singing, and realistic settings have not increased learning of factual information (Hoban & Van Orman, 1950; Travers, 1967). However, we hypothesize that realistic dramatic sequences may have considerable value in increasing interest, motivation, emotional impact, and in changing attitudes. The effects of music on these same variables can likewise be very powerful, but music and audio, features that the videodisc can readily deliver, deserve a separate study and could not be included in this one.

Dynamic Computer Graphics

Computer graphic terminals are rapidly becoming more sophisticated and available. These terminals and corresponding software make it possible for students to generate dynamic graphics specified by variable parameters (Kay, 1977). Three dimensional line drawings of automobiles, buildings, city streets, aircraft carrier decks, etc. can be created, displayed and manipulated (See Figure 1). These drawings can be rotated and viewed from several perspectives. Little is known about the effects of such graphics on learning or performance. Interactive graphics seem to have great potential, but further research is required to determine appropriate guidelines for their use.

Learner Characteristics

Moore and Nawrocki (1978) reviewed the literature to determine the relationship between individual differences and instructional graphics. Many significant aptitude by treatment interactions (ATI) were found. However, they concluded that while ATI methodology appears promising, those learner characteristics relevant to the use of instructional graphics have not yet been clearly identified.

Allen (1975) also conducted an extensive review of the literature on the interaction of intellectual abilities and instructional media design. The majority of his findings and conclusions deal with such variables as advanced organizers, organizational outlining, attention-directing procedures, active response, posing questions, and corrective feedback. However, he did address a few variables more relevant to the role of graphics in instruction: graphics complexity, motion, redundancy and repitition, and pacing. Allen concludes that individuals of high mental ability appear to benefit more from complex, fixed-pace, motion graphics than do individuals of lower ability. The learning of low mental ability individuals seems to be deterred by the use of either verbal or visual displays which are so complex, fast-paced, or information rich that their information-processing capabilities are exceeded.

Dwyer (1978) reported several studies which examined the interaction of reading comprehension, intelligence, and entering behavior with various types of graphics displays. In terms of the interactive effects of reading comprehension and graphics complexity (realism) on student achievement, he reports the following conclusions from a study conducted by Parkhurst (1976): (1) On most criterion tasks employed, the less realistic (less complex) graphics reduced the overall differences between reading level groups; (2) The high reading level group's achievement improved as the degree of realism increased; and (3) The low reading level group's achievement on the criterion tasks decreased as the realism increased.

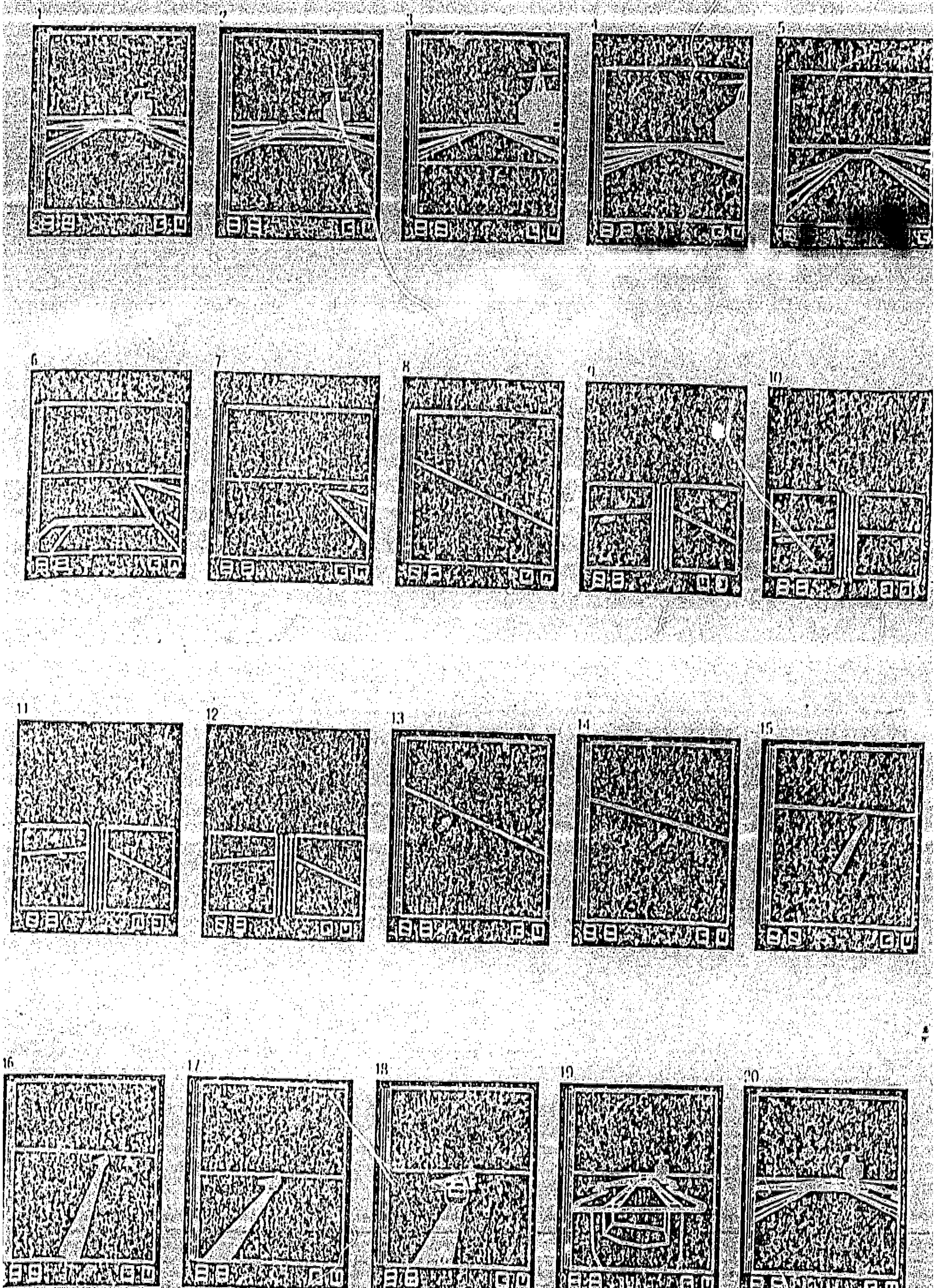


Figure 1. Graphics from a computer simulation of takeoff and landing on an aircraft carrier (From Sutherland, 197[illegible]).

In terms of the interactive effects of intelligence and levels of graphics realism, Dwyer, (1976) concludes that although students of higher intelligence constantly achieve as well or better than others, a simple color line drawing was the most effective type of graphic for all students on five different criterion measures. In another study (Dwyer, 1975) the interactive effects of entering behavior and degrees of realism were investigated with self-paced instructional materials. Conclusions from this study were: (1) Students with high entering behavior consistently scored as well or higher than students with low or medium entering behavior; and (2) The simple, color line drawing was generally the most effective across various criterion measures and levels of entering behavior.

Based on Allen's (1975) and Dwyer's (1978) reviews, individual differences do interact with various types of graphic displays. However, across all studies which used various types of individual difference variables, simple line drawings (color or black and white) appear to be the most effective type of graphic for increasing achievement on all criterion measures for students at all levels. Since computers with even moderate graphics capability emphasize simple line figures, this finding has relevance for both the production of images for the videodisc and the generation of images in real time by the computer.

Most educators would agree that individual differences do exist and that instructional systems should be designed which take into account these differences. Cronbach and Snow (1977) have suggested that enough treatments should be designed so that individuals could be assigned into a treatment where they will be able to succeed. However, Bunderson (1973), and David Merrill (1975) have proposed an alternative approach. (See also Bunderson and Foust, 1976). These writers suggest that rather than assigning students to a small number of alternate treatments, students should be allowed to select that treatment or strategy which would be most appropriate for them at a given point in time. The range of possible options open to students could be theoretically infinite if the students were allowed to select and sequence individual displays or short presentations into their own unique instructional strategy or treatment. Such a "learner control" system would offer an infinite range of treatments from which the learners could tailor one to meet their individual needs. Thus a student with high reading ability could select complex, realistic graphics while a lower ability student could select simple graphics. The relative costs of these alternatives should receive further investigation.

It seems to be generally assumed that the use of graphics will facilitate the learning of those who have poor reading ability. However, this assumption was not substantiated in the study reported above by Parkhurst (1976). He found that achievement actually decreased for poor readers as the degree of realism increased from no visuals to the realistic model. This was not the case for students with medium or high reading ability. These results might be explained by Samuels' (1970) contention that pictures and text compete for the learner's attention and that pictures serve as a crutch and distract the poor reader from attending to and learning the words. Further research needs to be conducted to verify these findings and determine the causal factors behind such effects.

Further research is also needed to determine if an individual difference variable, such as visual literacy, interacts with the effectiveness of instruction that includes graphic displays.

A summary of the General Guidelines is presented on the following page.

General Guidelines

1. Gaphics are not necessary and may actually be distracting if they are used as signs for concepts, objects or events with which the learner has had considerable previous experience. Under such conditions, the added external visual or graphic is redundant with the learner's mental visual image, and thus may not facilitate performance. Graphics become helpful and vital when the learner is exposed to new concepts, objects, or events for which he has no labels and/or corresponding visual imagines.

2. Pictures, color, realism, and motion generally increase the attraction and interest value of materials, are preferred by learners of all ages, and may significantly reduce attrition from training courses.

3. In general, color has little demonstrated effect on performance but may enhance learning when used to emphasize relevant cues and when actual color discrimination is required.

4. Motion generally has little effect on learning except when the information to be learned deals directly with motion or change. However, we hypothesize that realistic dramatic sequences may have considerable value in increasing interest, motivation, emotional impact, and in changing attitudes.

5. Interactive, dynamic, computer graphics offer a unique but largely unknown training application potential.

6. Complex, fixed pace, motion graphics may be beneficial for individuals of high mental ability but may deter learning for individuals of lower mental ability.

7. Simple line drawings, color or black and white, appear to be the most effective type of graphic for increasing achievement.

8. A learner control system which allows students to select that treatment which would be most appropriate for them at a given point of time may be more effective than assigning students with different abilities to a small number of alternate treatments.

Specific Guidelines for Employing Graphics

This section proposes more specific guidelines for using graphics under given conditions than the guidelines found in the previous section. These specific guidelines will be based on a taxonomy of training objectives. The most generally recognized taxonomy within the academic community has been developed by Bloom (1956); however the taxonomy introduced by Gagne in 1965 and updated several times (e.g., Gagne, 1977), is generally seen as lending itself better to prescriptions. Gagne proposed five major domains of training objectives: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. The intellectual skills domain has been further divided into the subcategories of discriminations, concrete concepts, defined concepts, rules, and higher order rules.

Aagard and Braby (1975) have developed a taxonomy of types of training objectives that is similar to Gagne's taxonomy but which more closely corresponds to tasks commonly found in the military. Aagard and Braby's taxonomy has been incorporated with minor modifications into the Interservice Procedures for Instructional Systems Development (IPISD) described in Tradoc Pamphlet 350-30 (1975).

The taxonomy used in this report is identical to that outlined in Tradoc Pamphlet 350-30. The use of this taxonomy should facilitate the integration of the guidelines presented in this report with the overall Instructional Systems Development (ISD) procedures presently being utilized to develop instructional materials in the Army. The taxonomy used in this report focuses on the "task requirements" factor identified by Moore and Nawrocki (1978) as relating to the effectiveness of graphics in training. The "subject matter content" factor will be treated where appropriate within the various categories of objectives. The third factor specified by Moore and Nawrocki, "learner characteristics", was addressed in the previous section.

The following subsections will describe principles and guidelines for using graphics in instruction related to the following eleven training objectives: rule learning and using, classifying, identifying sumbols, detecting, making decisions, recalling bodies of knowledge and using verbal information, performing gross motor skills, steering and guiding-continuous movement, recalling procedures-position movement, voice communicating, and attitude learning.

Rule Learning and Using

Rule using behavior occurs when a trainee is able to respond to a class of stimulus situations with a class of performances, the latter being predictably related to the former by a class of relations (Gagne, 1977). Rule using behavior is involved in such Army tasks as spelling words, using proper grammar, performing mathematical operations, determining the proper aiming of an artillary piece in order to hit a target at a given distance, choosing a course of action based on conditional rules, etc. Thus, the rule or relation "i before e except after c," enables a trainee to respond correctly to an entire class of stimulus words containing the letters ie and ei.

Usually the most effective instructional strategy for teaching rules involves: (1) the presentation of a verbal statement of the rule, (2) a demonstration of the application of the rule to several example problem situations, (3) the provision of several unencountered problem situations where the trainee is asked to practice applying the rule, and (4) the provision of corrective feedback.

The role of graphics in teaching rules depends upon the nature of the class of stimulus situations corresponding to the rule and the nature of the demonstration required to show the application of the rule. If the stimulus and demonstration only involve symbols and their manipulation as in spelling, grammar, and mathematical rules, then graphics are generally not necessary for effective instruction.

On the other hand, if the stimulus and/or demonstration involves actual objects and their manipulation, then the actual objects or a pictorial representation or simulation may be required. However, if the class of stimulus situations consists of real objects, and the class has been previously learned as a concept, then pictorial representations of the stimuli would not be necessary. For example, instruction on the "selection of proper fire extinguishers for different types of fires" would only require pictorial graphics if the types of fire extinguishers and fires had not been previously learned or could not be recalled. (See section on Classifying).

Complex rules often involve a series of operations and conditional decision points. Such rules are actually procedures. Verbal statements of these procedural rules are generally difficult to understand. Learning of these rules can be facilitated through the use of algorithmic representations such as flow charts which graphically portray the order of the operations and alternate paths which should be taken based on the conditional decisions (See the section on Procedures).

Classifying

Classifying behavior occurs when a trainee is able to correctly identify which of several unencountered objects, events, or symbols (or a representation or description of such objects, events, or symbols) is a number of a given class. Correct classification behavior is the most appropriate indicator of a trainee's understanding of a concept.

Classifying behavior is required in a great number of Army tasks and is often prerequisite to the learning of other behaviors such as rule using, decision making, and procedure execution. For example, soldiers may be required to classify examples of enemy aircraft, tanks or ships into particular categories. By classifying a specific tank into a particular class, it would be possible to determine the tanks maximum speed, firing range, limitations, etc. A misclassification could lead to erroneous conclusions and inappropriate decisions and actions. Classifying behavior is also involved in identifying particular parts of a piece of equipment, identifying particular malfunctions in equipment, identifying proper camouflaging, etc.

Several studies, (Tennyson, Woolley, and Merrill, 1972; Tennyson, 1973) have shown that concept learning is greatly facilitated by showing the trainee several divergent examples and matched non-examples and then allowing him to practice classifying unencountered examples and non-examples. Pictorial representations should be used as examples in the initial learning of concepts which have concrete referents (Levie and Dickie, 1973). In general the pictorial representations used as examples should be simplified so that the number of irrelevant cues is reduced and the redundancy of relevant cues is increased (Levie and Dickie, 1973; Black, 1962; Travers, 1967; Dwyer, 1978). If the example is too complex or realistic it may be difficult to perceive and distinguish the attributes of the example which are critical to appropriate classification. This is especially the case in fixed-pace presentations where the trainee cannot contol the rate of exposure. However, as training progresses, more difficult and complex examples should be used which approximate the real world environment or task. Actual objects or realistic representations could be used at the beginning of training to add interest, to motivate the student, and to provide an orientation to the real world. Simplified representations could then be used to isolate and highlight the critical attributes, followed by more realistic representations to facilitate transfer. Critical attributes could be highlighted through the use of other graphic elements such as arrows, texture, shading, or color (May, 1965).

In general, pictorial representations are not useful for teaching intangible or abstract concepts such as democracy, freedom, guilt, ego, government, management, etc., which do not have concrete referents (Levie and Dickie, 1973). Verbal definitions are usually necessary to present the critical attributes of such concepts. These concepts may be best exemplified through the use of stories and analogies.

Identifying Symbols

The principal behaviors involved in identifying symbols are multiple discrimination behavior and classification behavior. If the symbols to be identified have very little variance in perceived appearance from one occasion to the next, then multiple discrimination is required. However, if several symbols which differ in appearance are to be treated as a single class, then classification is required (see Classifying section). However, it should be noted that multiple discrimination is a prerequisite to classification. Identifying symbols is involved in such Army tasks as reading electronic symbols on a schematic drawing, identifying symbols on a topographical map, recognizing the insignia on an officer's uniform, etc.

Although it may be possible to describe certain simple symbols verbally, learning will be much more efficient if graphics of the actual symbols are used (See Figure 2). Only three to seven symbols should be taught simultaneously. Once these are learned, new symbols may be added with regular review of those previously learned. Multiple discrimination is basically a paired-associate task and requires considerable drill and practice where the trainee is repeatedly shown the symbols to be learned in random order and is asked to respond with the appropriate label that corresponds to each symbol. When an error is made, corrective feedback should be given. Flash cards with symbols on one side and the correct label on the back would be helpful in learning to identify symbols. An enhanced version could be implemented easily on videodisc or computer.

If identification of a symbol requires color discrimination, then color should be used (Travers, 1967). Motion would only be necessary if movement were a critical attribute required for proper discrimination. If the movement involved is fairly simple, it could be indicated adequately through the use of arrows on still graphics (See Figure 3).

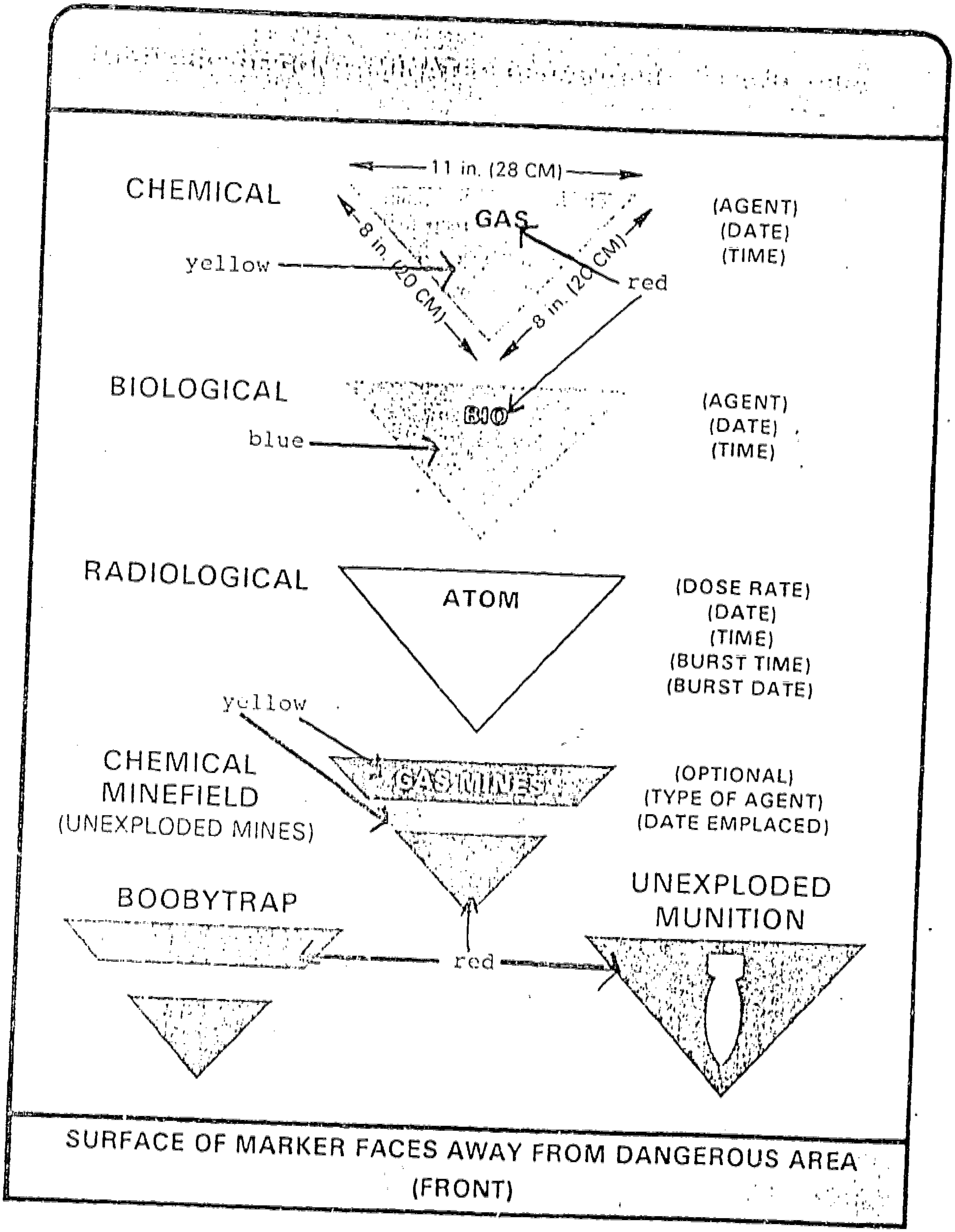


Figure 2. Graphic of colored symbols.
(From Dept. of Army, Oct. 1977)

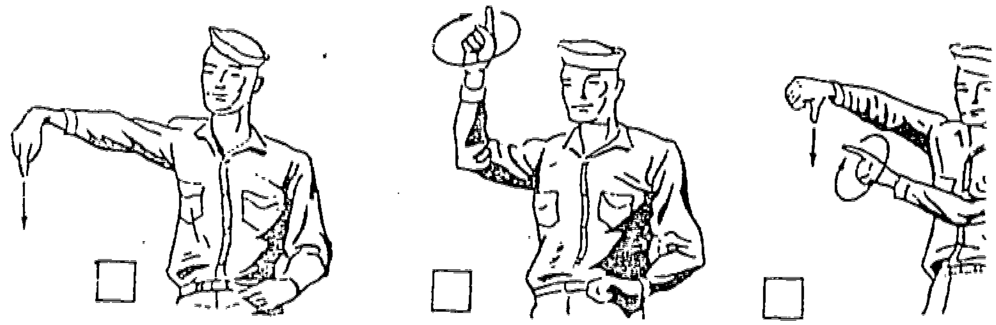


Figure 3. Still graphic of simple movement indicated by arrows (TRADOC, 1975)

However, portions of both practice and the criterion tc should require the trainee to identify the symbols in actual motion, if the objective requires much skill.

Detecting

Detecting behavior involves multiple discrimination or classification behavior in a high noise environment whe the things to be detected are embedded in a large block time and/or space. Detecting behavior is involved in s Army tasks as early radar detection of an aircraft targ detecting movement of enemy vehicles at a distance duri twilight hours, etc.

The role of graphics in the initial stages of instructio detecting behavior would be very similar to those outli in the sections on identifying symbols and classifying. However, later stages of instruction should incorporate the noise and time aspects, which can often be done by simulation. Graphics of the object would need to be re tic in terms of both the object itself and the natural noise of the environmental setting. Graphics which inc the objects should be inserted randomly in a series of graphics showing the environmental setting withoug the ject and the trainee should practice detecting the grap which include the object. Final stages of training sho involved the detecting of real objects in their natural environment.

Making Decisions

Making decisions involves the selection of possible solutions to an identified problem. The process involved is often classified as problem-solving. In rational decision-making or problem-solving an individual would: (1) identify the nature of the problem; (2) collect information or data relevant to the problem; (3) develop alternative solutions to the problem by identifying and combining previously learned rules; (4) evaluate, test, or compare the various solutions; and (5) select the most appropriate alternative which would solve the problem.

Decision making involves more than applying a previously learned rule to solve a specific problem which belongs to a class of problems known by the individual to be solvable using the given rule. Decision making also requires the identification and generation of solutions to novel problems. Decision making is required in such tasks as choosing torpedo settings during a torpedo attack, choosing appropriate combat tactics, choosing a diagnostic strategy in dealing with a malfunction in a complex piece of equipment, etc.

The most effective strategy for teaching decision making skills is to provide the trainee with a wide variety of appropriate decision making situations. These situations should be novel and unencountered and correspond to the trainee's capabilities. In early stages of learning it is often necessary to provide some guidance to the trainee to channel their thinking in fruitful directions. However, this guidance should not present the actual solution to the problem.

The role of graphics in decision making training is highly dependent on the nature of the decision making situations presented to the student. If the information or data relevant to the decision is verbal or numerical in nature then graphics may not be necessary or useful. However, relationships among numerical data sets may be best understood when represented by a line graph which shows trend directions. In addition, if the decision situation requires the use of data that involves the perception of characteristics of objects or events then the use of graphics might be required. On the other hand, if trainees have had considerable experience with the relevant objects or events such that they could mentally visualize the characteristics from a verbal description, then graphics may not be necessary.

Recalling Bodies of Knowledge and Using Verbal Information

A trainee who can recall bodies of knowledge or use verbal information is able to tell, state, or verbalize a fact or idea in the form of a proposition. Generally it is not necessary that the proposition be restated exactly word for word. (Notable exceptions include recitation of a poem or famous speech or relating a coded message.) However, it is necessary that the restatement of the proposition in the trainee's own words convey the same meaning as the original fact or idea. Verbal information may be classified into three subcategories: (1) names or labels, (2) facts, and (3) collections of facts organized as connected discourse (Gagne, 1977). Recalling verbal information is involved in such tasks as stating the name of a particular building or mountain, listing the six principles of war, or describing the major campaigns in World War II.

Learning the name or label for a single object is quite an easy task. However, the task becomes difficult if several different names must be learned for several different objects at the same time. Confusions occur because of the process of interference. This interference can be overcome by making the association between the label and object more distinctive or meaningful.

Verbal information is more easily learned and recalled when it is "meaningful". Real words are easier to remember than nonsense syllables, and words which form sentences are easier to learn and recall than random word lists of the same length. Labels are easier to learn if they can be meaningfully connected to the corresponding object through the use of mediating verbal links or images. These mediating links may include various mnemonic devices. The learning of facts is facilitated if they can be related or subsumed (Ausubel, 1968) into an already existing cognitive structure.

The learning of verbal information is often aided by the use of some organizational device. Facts organized by topic sentence may be learned more efficiently than those presented without a topic sentence (Gagne, 1968). A graphical representation of the relationships between facts can provide organization and meaning which facilitates the storage and retrieval of verbal information (Holliday, 1976). Examples of such diagrams are found in Figure and 5. When a large amount of numerically related information is being presented, the use of tables, charts or graphs may provide a more efficient means for organizing materials and depicting relationships. Maps can be very efficient and vital representations of many different types of spatial infor-

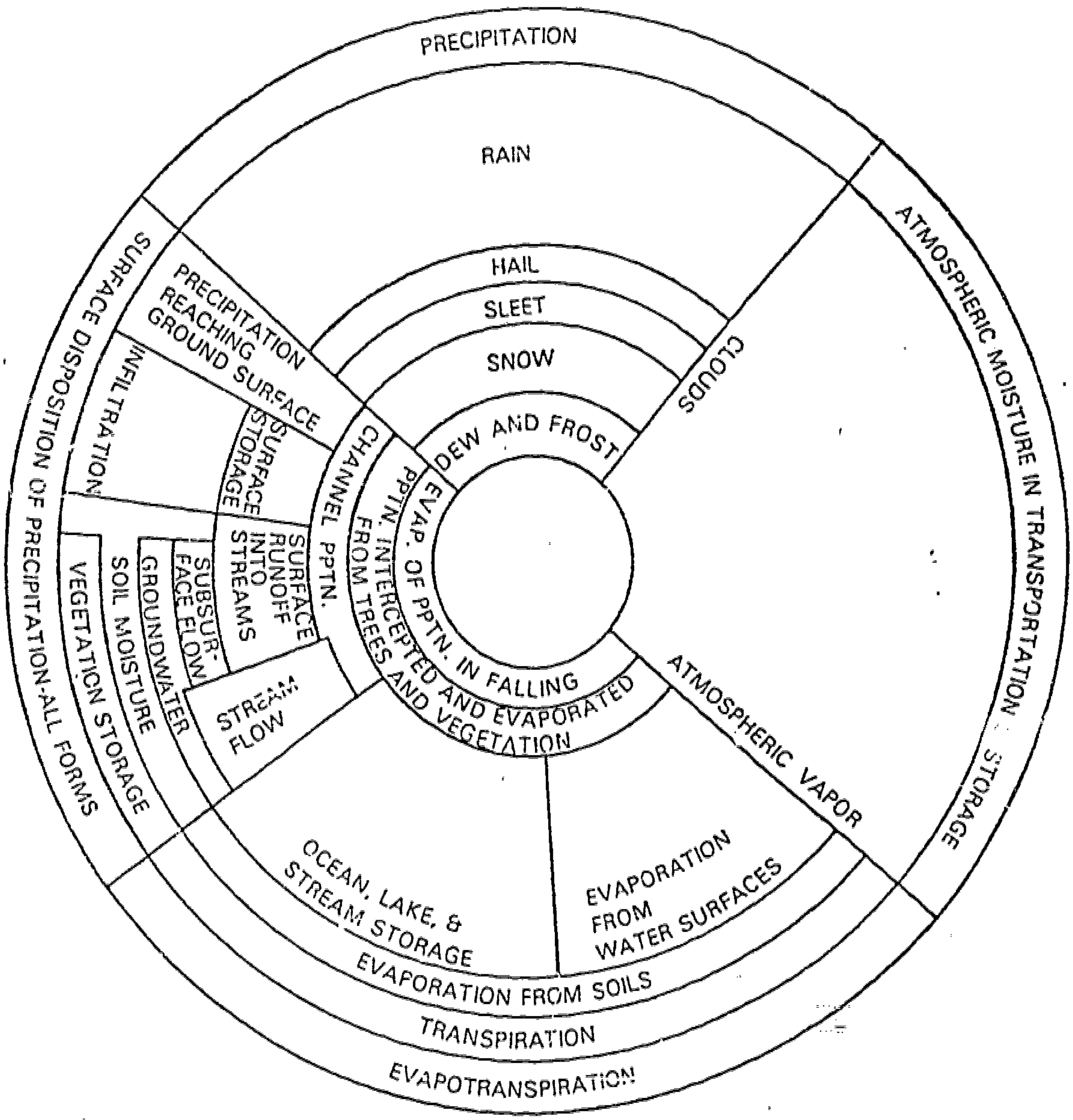


Figure 4. Graphic showing organization of verbal information (Adapted from Horton, 1931, by Hart and Merrill, 1978).

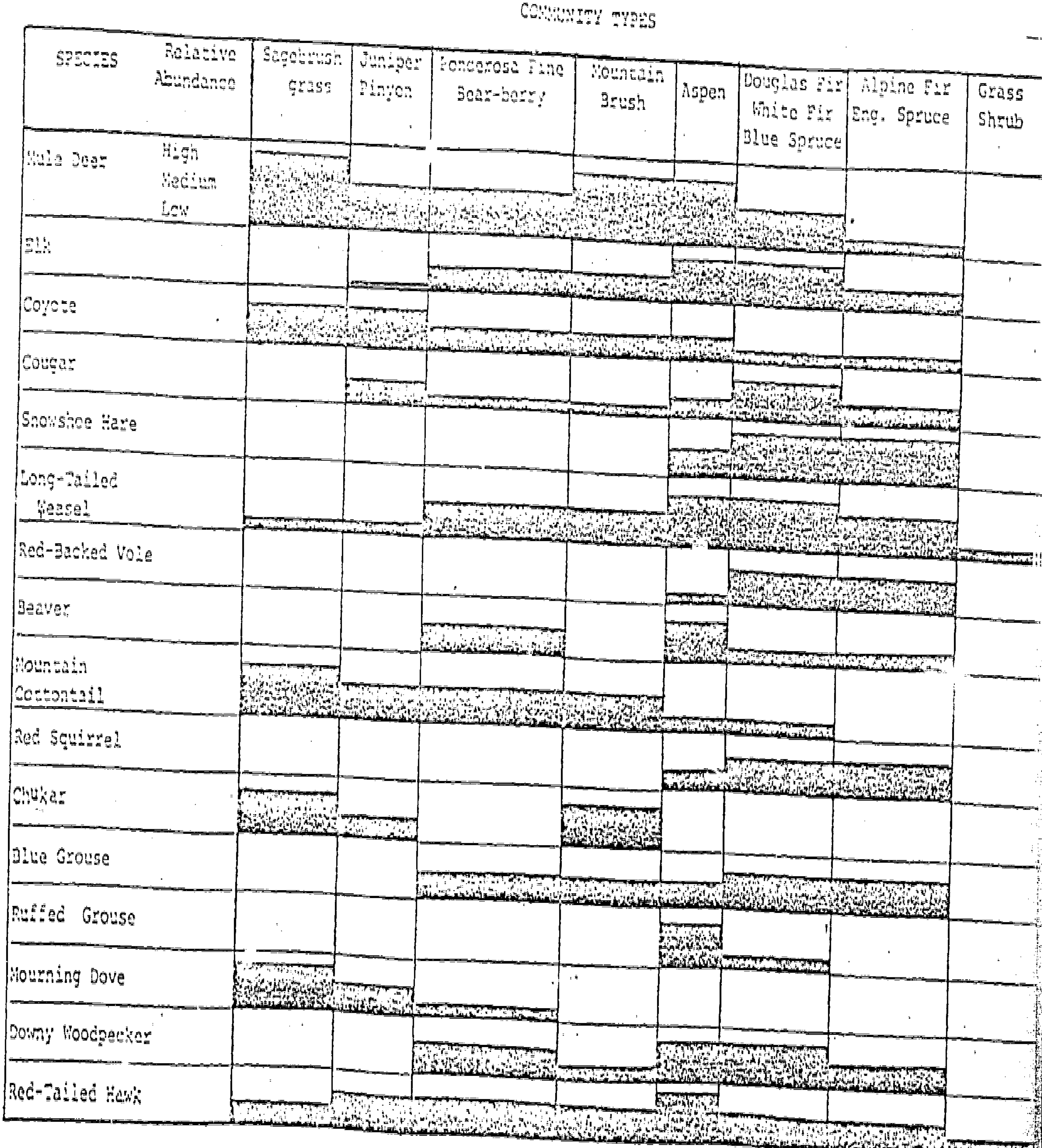


Figure 5. Graphic showing tabular organization of verbal information (From Smith, 1978).

mation, while tables and charts are vital representations of complex time schedule information. However, explanatory information and examples should be provided to assist trainees in reading any tables, charts, maps, or graphs used. Further prescriptions on the use and construction of tables and figural graphics can be found in McDonald-Ross's (1977a, 1977b) recent reviews.

Pictures or line drawings are often inserted in textual verbal information material for illustrative purposes (Figure 6). Although these illustrations may increase interest and enjoyment they may not increase understanding or learning. This is often the case because the illustration shows an example of a concept which has been previously learned by the trainee or could have been easily visualized in the mind of the trainee from the verbal description provided in the text. Some illustrations which are added to spruce up the text may actually be confusing or distracting. An example of such an illustration is shown in Figure 7.

However, Levine and Lesgold (1978) recently reviewed twelve studies which showed that pictures facilitated prose learning of unfamiliar fictional narratives presented orally to elementary school children. The pictures were consistent with and redundant to the story content. Cued factual recall questions were used in the achievement instruments. In these studies the pictures may have helped illustrate unfamiliar concepts.

Neither color nor motion has been shown to facilitate the learning of verbal information. However, color and motion may affect attention and attrition.

Performing Gross Motor Skills

Motor behavior occurs when a trainee is able to execute a physical movement with precision and appropriate timing. Motor skills are involved in such Army tasks as: marching, swimming, painting a barracks, typing a report, operating a piece of equipment, using hand tools, adjusting a microscope, etc. Motor behavior often involves the execution of a series of several coordinated movements. The order in which these individual movements are performed may be taught independently from the actual movement. For example, the order in which the parts of a rifle are assembled may be taught independently from the motor skills required to put the parts together. The role of graphics in teaching procedures is described in another section.

It is difficult to imagine a trainee being able to learn a complex motor skill solely from verbal or textual infor-

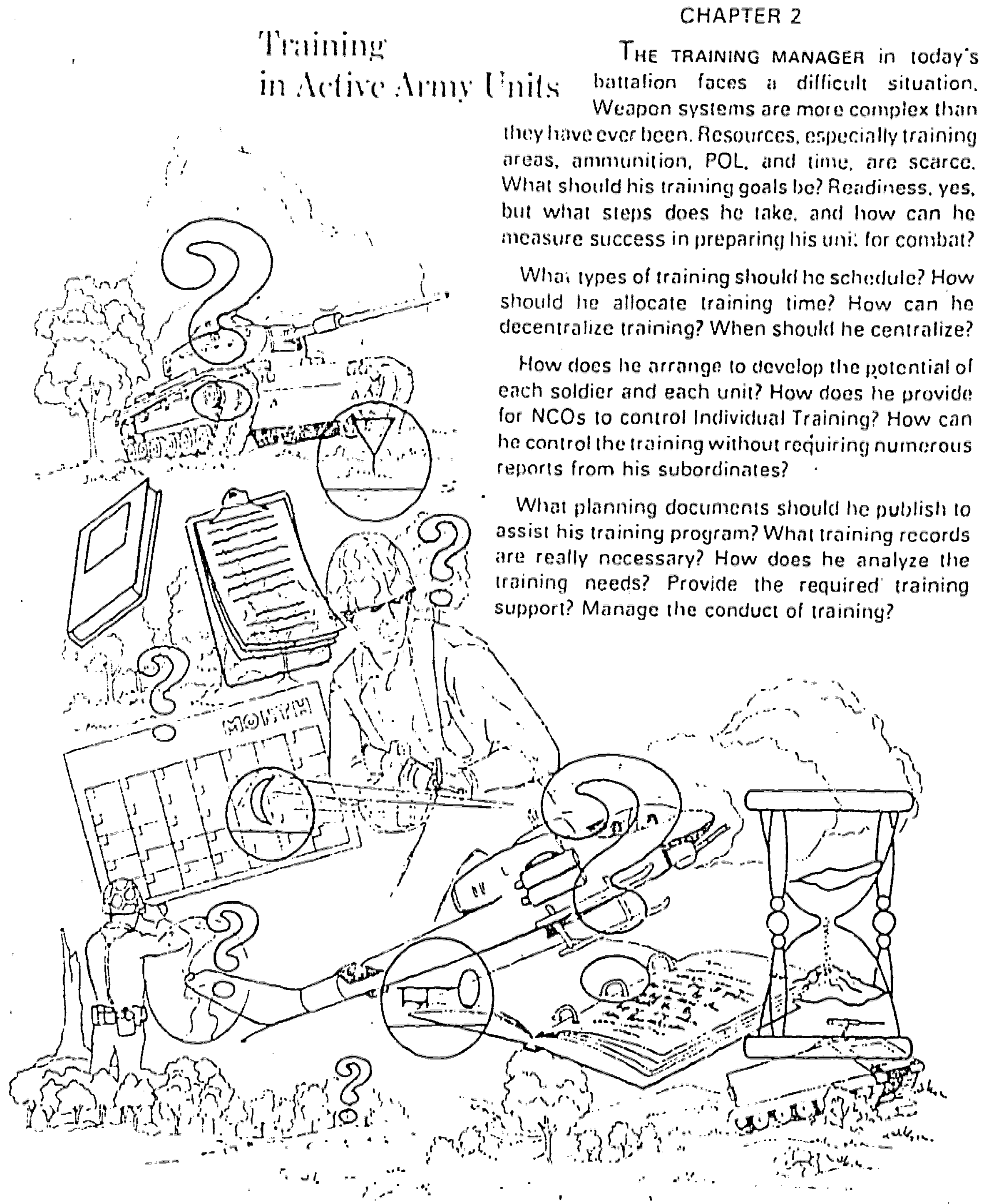
goals — parents want children who are only well behaved; teachers want only quiet classrooms or students who will do and say what the teachers want; administrators want subordinates who will obey without question, who are yes-men. One way to achieve these goals is to create dependency in others. Interestingly enough, many dependency-producing leaders never recognize their part in the problem, for they will often exclaim sadly, "What we need is more people who will take initiative and won't just sit around waiting to be told what to do."

Counterdependence

In the other behavioral stream is the desire to be free, to "let me do it by myself." Some have postulated, as did the English philosopher Thomas Hobbes, that by his very nature a man is at war with everyone else as each tries to hammer out his own ego-centered world. If everyone actually were to do only what he wanted, without taking others into account, the result would be anarchy.

As managers see in their subordinates the tendency to seek free-

Figure 6. Neutral graphic used to illustrate text (From Dyer, 1976).



CHAPTER 2

Training in Active Army Units

THE TRAINING MANAGER in today's battalion faces a difficult situation. Weapon systems are more complex than they have ever been. Resources, especially training areas, ammunition, POL, and time, are scarce. What should his training goals be? Readiness, yes, but what steps does he take, and how can he measure success in preparing his unit for combat?

What types of training should he schedule? How should he allocate training time? How can he decentralize training? When should he centralize?

How does he arrange to develop the potential of each soldier and each unit? How does he provide for NCOs to control Individual Training? How can he control the training without requiring numerous reports from his subordinates?

What planning documents should he publish to assist his training program? What training records are really necessary? How does he analyze the training needs? Provide the required training support? Manage the conduct of training?

Figure 7. Distracting graphic (From Dept. of Army, 1977).

mation. The movements must be demonstrated to the student either by an instructor or through the use of some pictorial representation. In some situations, a live demonstration may not be ideal if model is unable to perform the movement slowly enough for the trainee to see the critical aspects of the movement. The serving of a tennis ball is difficult to demonstrate for this reason. A series of still pictures which show critical positions or aspects of the movement in diserete intervals across time may be more instructive (see Figure 8). Frazier (1978) refers to this as pseudo-animation. If care is not used with pseudo-animation, the critical continuity of the movement may be lost. A motion picture has some of the same advantages and disadvantages of a live demonstration. If the movement is shown in real time, it may be too fast. However, slow motion would demonstrate the continuity of the movement while slowing it down so that the critical aspects could be perceived. Repetitions of the demonstration or motion picture can improve the learning of motor skills (Hoban and Van Orman, 1950). Learning may also be facilitated if the trainee can stop the motion picture film and practice the motor skill rather than trying to practice the skill while the film is in progress. Even mental practice, where the learner thinks through the various motions may be effective (Travers, 1967; Bandura, 1977). The videodisc may make a significant contribution in this learning area as it has capabilities for slow motion and freeze frame which videotape and film do not.

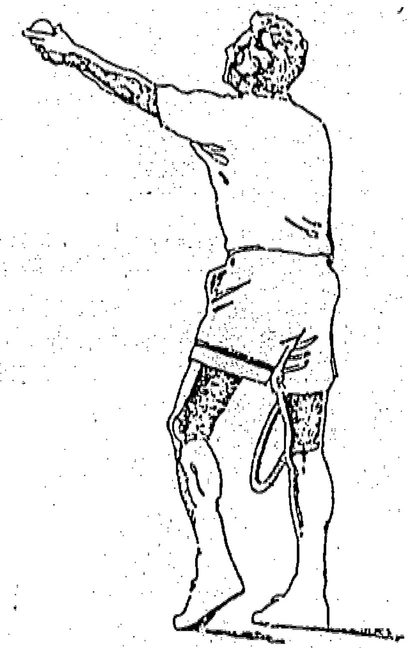
Practice is crucial in the learning of a motor skill. However, practice is only beneficial if the learner receives some feedback. This feedback may be intrinsic to the task as when the correct letter is typed on a piece of paper, or may require the judgment of an instructor. Many complex motor skills are difficult to learn because trainees cannot totally observe their own responses and thus are unable to compare their responses with the correct form (Bandura, 1977).

This problem could be alleviated by videotaping the trainees performance and using the videotape for feedback.

Steering and Guiding-Continuous Movement

Steering and guiding behavior involves a perceptual-motor skill where the trainee must continuously scan or monitor certain external cues and execute appropriate movements on a continuing basis in accordance with the perceived cues. Such skilled behavior is required in driving a tank down a road, landing an aircraft, tracking an air-to-air gunnery target, etc.

1. This is the start of the forward-back-forward, roundhouse, rock-and-roll service action that I advocate, particularly for smaller players. Both arms are extended toward the net and the weight is on my front (left) leg as I lean forward.



2. My body straightens and the weight shifts to the back (right) leg. As the racket arm comes down, the toss arm comes up. Both arms move in unison, although the motion of the right arm will shortly accelerate.

3. Now my knees bend and the racket arm swings almost straight back as the ball is tossed by thrusting my left arm upward. At this stage my racket is well behind my body, in a more accentuated style than most players use, commencing the full, free swing I prefer.

4. Here I am into the called crouch. The knees are flexed even further and the back is arched like a spring. My right elbow has bent to start the racket head down behind my back.

Figure 8. Series of Still Graphics Showing Sequence of Movements (From Segura & Heldman, 1976).

Steering and guiding behavior involves a combination of the skills described in the sections, "Performing Gross Motor Skills," and "Detecting." The relevant cues are embedded in a high noise environment and in a large block of time and space. These environmental cues then serve as signals for the execution of the appropriate motor skills.

In the early stages of training, the detecting of relevant cues could be taught independently of the motor skills using graphics as described in the section on "Detecting." The motor skills could be taught as described in the section on "Motor Skills." The intermediate stages of training should integrate the detecting of cues with the corresponding motor skills. The integration of these skills could take place in a training simulator such as the Link Trainer.

In the final training stages, the learner should be given opportunities to practice and demonstrate proficiency in a realistic setting. Practice and corrective feedback are absolutely essential.

Recalling Procedures--Positioning Movement

A procedure is a series of steps or operations for performing a task. The steps of the procedure may be cognitive, psychomotor, or a combination of both. A procedure often involves decision points with alternate paths. If the procedure involves motor skills which have not been previously learned, then instruction for motor skills will be necessary (see section on Motor Skills). If the procedure involves the set up, operation, assembly, disassembly, or maintenance of a piece of equipment, then the trainee must learn how to identify or classify the relevant parts of the equipment used or involved in the procedure (see section on Classifying).

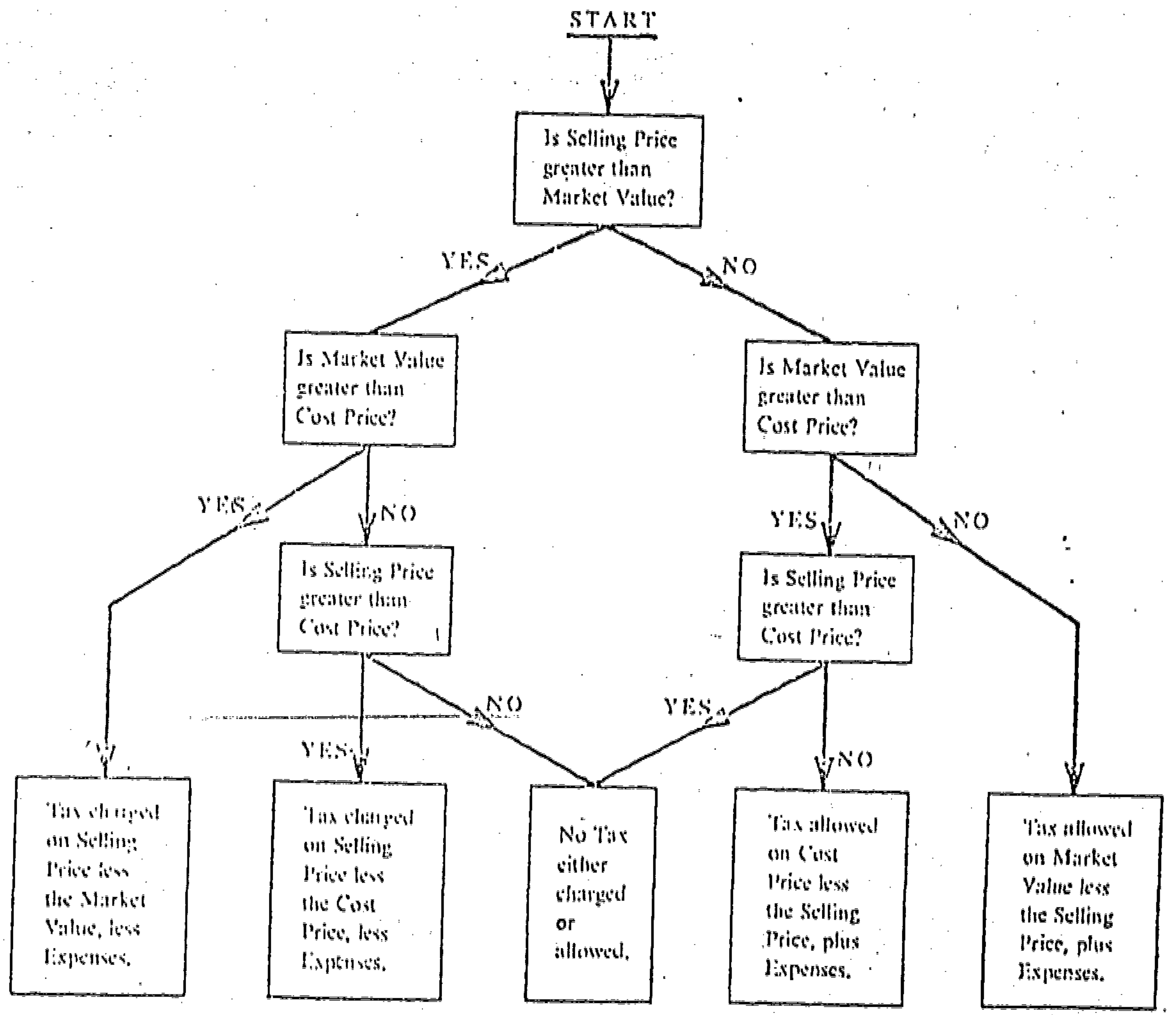
The actual steps and the order of the steps which make up the procedure may be represented in several ways. If the procedure is fairly simply, the steps may be presented as textual prose. However, more extensive linear procedures are easier to understand if the individual steps are separated and presented in a list format. If the procedure involves several decision points and loops (the same steps are repeated several times) then a figural graphic such as a flow chart or decision table will facilitate learning. For example, Lewis and Horabin (1967) found that calculating the amount of tax owed was greatly facilitated through the use of a flow chart diagram (see Figure 9 and 10).

If the asset consists of stocks or shares which have values quoted on a stock exchange (see also paragraph G below), or unit trust units whose values are regularly quoted, the amount of tax chargeable or allowable depends upon the relative sizes of the *cost price* of the asset, its *market value* on 6 April 1965, and the *selling price* of the asset.

If the selling price is greater than the market value, and the market value is greater than the cost price, tax is charged on the selling price less the market value (less allowable expenses). If the selling price is greater than the market value, and the market value is *less* than the cost price, two possibilities arise. Either the selling price is greater than the cost price, in which case tax is charged on selling price less the cost price (less expenses). Or the selling price is less than the cost price, in which case no tax is either charged or allowed.

If the selling price is less than the market value, and the market value is less than the cost price, tax is allowed on the market value less the selling price (plus allowable expenses). If the selling price is less than the market value, and the market value is *greater* than the cost price, two possibilities arise. Either the selling price is less than the cost price, in which case tax is allowed on the cost price less the selling price (plus expenses). Or the selling price is greater than the cost price, in which case no tax is either allowed or charged.

Figure 9. A simplified version of some official prose concerning the amount of Capital Gains Tax payable following the sale of an asset. (From Lewis & Horabin, 1967).



Note: 'Market value' is based on the quoted value at 6th April 1965.

Figure 10. Flowchart for Capital Gains Tax, the algorithmic equivalent of Fig. 9. (From Lewis & Horabin, 1967).

Many procedures are so complex and/or the consequences of error are so great that it is impractical to require trainees to memorize the sequence of steps. In such cases, a job aid which lists the steps or presents a flow chart of the steps should be used.

If the procedure involves extensive motor skills, the steps of the procedure and the motor skills could be taught simultaneously by live demonstration, motion pictures, (with slow motion if real time is too fast), or with a series of still pictures (see section on Motor Skills). If film or pictures are used to demonstrate the steps of the procedure, the performance should be photographed so that the representation shown has the same view or angle that the trainee would see if he were doing the procedure himself. (Hoban and Van Ormer, 1950). The videodisc allows for a combination of slow motion and still graphics that was difficult, if not impossible, with previous technology.

If the procedure involves the assembly of a piece of equipment with many parts and the motor skills required already exist in the repertoire of the learner, graphics would not be necessary to show the actual motor skills required. However, graphics would be necessary to show the various parts of the equipment and their relationship to each other (see Figure 11). The graphics would need to be supplemented with verbal or textual instructions which list the order in which the various parts should be assembled.

Whenever feasible, the trainee should be given opportunities to practice performing the procedure using equipment. In any case, hands on performance testing should be included to insure learning transfer has occurred.

Voice Communicating

Voice communicating involves the use of speaking and listening skills. Voice communicating tasks include giving oral orders and receiving oral orders, communicating or receiving information over a telephone, giving instructions to a pilot landing an aircraft via radio, etc.

Training in voice communicating primarily involves the demonstration of appropriate voice procedures (tone, pattern, stress, enunciation, pauses, etc.), trainee practice in imitating the correct procedures, and provisions of corrective feedback. Although language laboratory audio equipment may be very helpful in voice communicating and training, graphics would seldom be necessary or useful. A possible exception is the use of tabular alphanumerics

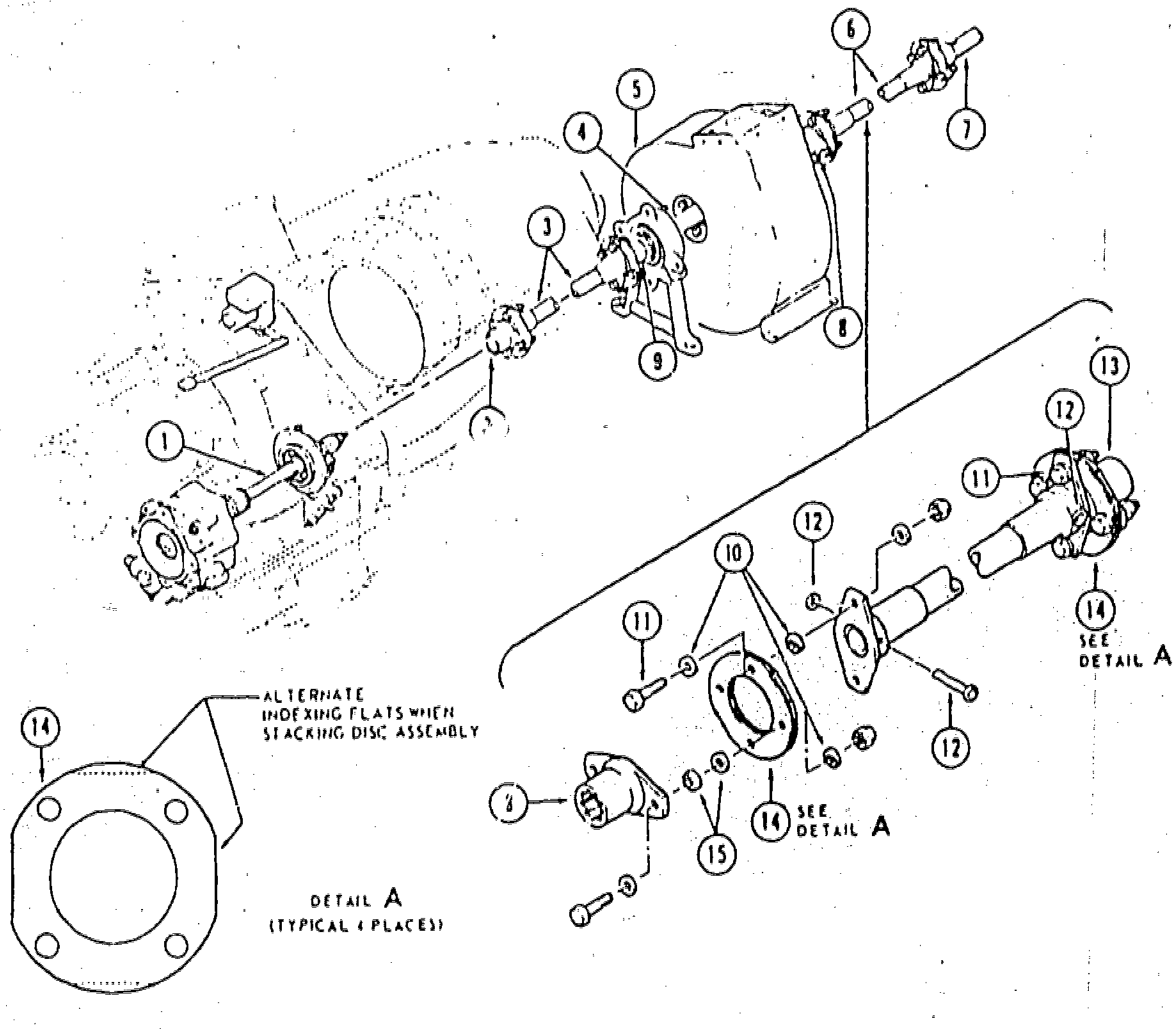


Figure 11. Graphic showing parts of a piece of equipment and their relationship to each other (From TRADOC, 1975).

for those tasks which require learning code words or phrases, particularly if such codes form information clusters.

Attitude Learning

An attitude is an internal state that influences an individual's choices of actions towards a class of persons, objects, or events. In effect, an attitude is a response tendency (Gagne, 1977). Possession of a high level of knowledge or skill does not ensure that an individual will always perform in accordance with that knowledge or skill. The purpose of instruction in attitudes is to strengthen an individual's internal state which influences his tendency to respond with the appropriate actions at the appropriate time and place. A change in attitude would be evidenced by an increase in the likelihood of appropriate performance. Attitude learning is associated with almost every other type of learning. Attitudes are involved in choices of action such as complying with safety procedures, conforming to dress, grooming, and cleanliness standards, abiding by security regulations, obeying commands and instructions of officers, taking risks to protect the lives of others, etc.

As mentioned above, communication of information and s. . i alone has little effect on attitude learning. Those learning situations which have had significant effects on attitude change include: (1) classical conditioning, (2) reinforcement or experience of success, and (3) human modeling (Gagne, 1977). Of these three, human modeling seems to be the most applicable, and probably the most effective approach for attitude learning. Attitude learning results in an imitation of the human model's choices of action. This imitation occurs only if the model has credibility and is admired and respected by the trainee. Attitude change is increased if the model is rewarded or punished for appropriate or inappropriate behavior or choices respectively (Bandura, 1969, 1977; Goldstein & Sorcher, 1974).

The credible human model may be presented in several ways: appear in person, in pictures, movies or TV, or merely described as in a novel, history text, or biography. It is not necessary for the human model actually to demonstrate the appropriate choice behavior; the model may only need to describe the situation in which he/she engaged in the desired choice behavior and indicate the reinforcing events that resulted from that choice (Bandura, 1977).

The principal aspects of human modeling can be demonstrated very effectively in motion pictures or television dramatic presentations. Realistic motion pictures are preferred by most individuals, can reach a large audience, and can portray consequences of certain choices of behaviors that would be too costly or unethical to demonstrate "live."

It is also important that the trainees be reinforced or experience success when they actually engage in the desired choice behavior which has been previously modeled (Goldstein & Sorcher, 1974). Such reinforcement will strengthen their attitude. Individuals enjoy and have a positive attitude towards those activities in which they are successful. Repeated failure will produce negative attitudes.

Most television commercials are excellent examples of the use of all three approaches to attitude change. The products are paired with positive situations, they are used or chosen by credible human models, and the models are reinforced for their choice of the product.

Graphic signs such as, "Keep off the grass" or "If you drink, don't drive," will have little effect in changing attitude. However, they serve as a reminder or reinforcer for those who already have some tendency in the desired direction. If the verbal message on the sign is accompanied by a picture of a respected human model, then some attitude change might occur.

Summary of specific guidelines for various types of training objectives

1. Rule learning and using. The learning of complex procedural rules can be facilitated through the use of representations such as flow charts which graphically portray the order of the operations of the procedure and alternate paths which could be taken at decision points.

2. Classifying. Pictorial graphics should be used as examples of concepts which have concrete referents. In the initial stages of training, simplified pictorial graphics should be used in order to isolate and highlight critical attributes. Later stages of training could employ more realistic graphics in order to facilitate transfer to the real world environment or task.

3. Identifying symbols. Considerable drill and practice with corrective feedback using graphics of actual symbols may be required in order to adequately learn how to identify symbols.

4. Detecting. The training of detecting behavior should involve the presentation of graphics within significant blocks of time and space which are realistic in terms of both the object itself and the natural noise of the environmental setting.

5. Making decisions. Training in decision making should involve instruction in the use and interpretation of various numerical relationships represented in both tabular displays and figural graphics.

6. Recalling bodies of knowledge and using verbal information. A graphical representation of the relationships between various facts and ideas can provide organization and meaning which may facilitate the storage and retrieval of verbal information. Pictures or line drawings inserted in textual, verbal information often have no effect on performance since they only illustrate concepts which could have been readily visualized from the textual description.

7. Performing gross motor skills. The demonstration of a complex motor skill in real time may be too fast. However, slow motion could demonstrate the continuity of the movement while permitting critical aspects to be perceived. A videotape of a trainee's motor skill performance may be a very valuable feedback device.

8. Steering and guiding-continuous movement. Graphics used to present the relevant cues for steering and guiding behavior should have a high relationship to real world noise and time conditions in the later stages of training.

9. Recalling procedures, positioning movement. If the procedure to be learned involves the assembly or disassembly of a piece of equipment with many parts, then graphics would be necessary to show the various parts of the equipment and their relationship to each other.

10. Voice communicating. In general, graphics would not be necessary in the training of voice communicating behavior.

11. Attitude learning. Human modeling seems to be the most applicable, and probably the most effective approach for attitude learning. Attitude learning involves the imitation of a credible and respected human model's choices of action. A human model may be presented in several ways: appearing in person, in pictures, in movies or TV, or merely described as in a novel, history text, or biography.

Graphics and the Videodisc

The introduction of the new videodisc technology will make possible several strategies for using graphics that heretofore have not been possible. The capabilities of the first generation players which are scheduled to be marketed by several companies during 1979 will allow a trainee to view normal speed motion sequences, stop a motion sequence on a single frame (freeze frame), step through single frames of a motion sequence in either forward or reverse order, view a motion sequence in slow motion (the slow motion speed may be varied from normal speed to four seconds per frame), randomly access any frame or sequence on the disc, and view motion sequences (either at normal or slow motion) in reverse, and view single frames which have been specifically designed to be viewed in still mode (still frames or video pages).

These capabilities will make possible the integration of motion sequences and still frames or video pages. The video pages can be used to present specially prepared text and graphics. These video pages can highlight certain aspects of the motion sequence or request the trainee to actively respond to questions or problem situations. The trainee can then be directed to additional alternate sequences on the disc depending on his response. Under a learner control strategy the trainee could randomly access any desired presentation form such as rule, example, and practice frames within a segment or branch to other lessons or units.

Standard motion sequences are often not effective in showing manual tasks which involve continuous movement because the real time motion is too fast for the trainee to see the critical aspects of the movement. Stopping and repeating the sequence is also quite cumbersome. The videodisc will eliminate these problems since the trainee will be able to adjust the speed of the motion sequence, stop on a single frame and look at the "frozen motion" for as long as he wishes, step through a series of frames one at a time, repeat the sequence in real time to see the continuity of movement (at any speed), stop a sequence to practice the movement, and then repeat the motion sequence for comparison with his own performance. The efficacy of this strategy should be investigated.

The videodisc in combination with a microcomputer will integrate the technologies of the book, television, and computer assisted instruction into one medium. This new medium will not only make available the new strategies for employing graphics described above, but will also provide for the display of graphics which have become commonplace in other media: books, television, computer graphics, slides, film strips, etc. Therefore, all of the guidelines presented in this report will have direct application to the development of training materials to be delivered via the videodisc technology.

Although educational technologists have struggled with the media selection question for many years, it seems to the authors that the question of graphics selection is much more relevant from an instructional effectiveness point of view. The characteristics of the visual display are often more critical for learning than are the characteristics of the medium. The media selection issue is treated at some length in volume II of this report. Media selection decisions are generally made based on availability, cost, administration, and logistic factors rather than according to some elaborate media selection model. This state of affairs would be reason for some concern if the same graphics materials could not be adequately displayed with many different media. With the advent of the videodisc, the issue may naturally shift from media selection to graphic selection, since the videodisc combines in one medium so many of the capabilities of other media. The purpose of this report is to present some preliminary guidelines for graphics selection which may facilitate this shift of emphasis.

Most models for designing training materials suggest that objectives be specified prior to the selection of graphics or media delivery systems. However, the objectives specified are necessarily constrained by the assumptions of the individual writing the objectives. The level of performance required of a student, and specified by an objective, could vary greatly depending on the tools or media assumed to be available for student use. For example, the types of problems students are asked to solve would depend on whether the problems had to be solved by hand, slide rule, calculator, or computer. The way in which a particular phenomenon could be shown and perceived, i.e., as a slow-motion picture, a dynamic computer graphic simulation, a still photograph, a line drawing, etc., would differ according to the availability of the real phenomenon. The availability of a powerful medium such as the videodisc with microcomputer may enable more sophisticated objectives to be achieved by the student than were possible with less versatile media. For example, simulations, which are extremely powerful instructional tools for many training objectives, can be designed and implemented for the intelligent videodisc.

If instructional designers begin with the assumption that a sophisticated delivery system is available, their vision of what is possible is expanded and their potential for generating more innovative and powerful strategies and outcomes is increased. It may later be possible to modify slightly sophisticated training materials for implementation on simpler systems. However, the modified version may be more powerful than what would have been developed if the version had been initially restricted by the assumption of a simpler delivery system. For example, a paper and pencil version of a computer simulation may be more powerful than a paper and pencil simulation that was developed without consideration of the complete modeling made possible with the availability of a computer. Thus, after materials are developed for the videodisc, it may be possible to spin off several alternate versions for other media which approximate the potential of the original videodisc version.

Although the videodisc can display most types of graphics, the videodisc picture is presently limited in the USA by the resolution of the NTSC television standard.* Thus certain graphics such as high resolution photographs may be difficult to adapt to videodisc. However, greater detail could be shown by zooming in on various segments of the photograph. A similar problem exists for the display of high resolution computer graphics. One alternative solution to this problem would be to use two different display screens, one for videodisc displays and another for computer graphics.

*See volume I of this report.

Research Implications

Although previous research on the effects of instructional graphics has provided some guidance for the identification of principles for using graphics, many of the assumptions about the inherent value of graphics for instruction are still unsubstantiated. Clearly, additional research needs to be conducted. However, more of the same type of research will probably produce more of the same ambiguous results.

Many of the studies reported in the reviews cited in this report dealt with laboratory tasks rather than actual training tasks. Such research may provide valuable knowledge for the development of learning theories, but it provides little guidance for the use of graphics in instruction. Significant advances were made in concept learning research when researchers (Merrill & Tennyson, 1977) began using classroom tasks rather than laboratory tasks (Bruner, Goodnow, and Austin, 1967; Clark, 1971). More graphics research needs to be conducted using actual training tasks.

As described in a previous section of this report, there should be a significant relationship between the task requirements or terminal objectives and the graphics used for instruction. Since criterion measure should match the terminal objective, there should also be a significant relationship between the graphics used for instruction and the criterion measures. If the criterion measures used in research studies do not require the use of graphics or use graphics different from those used in the experimental treatments, the results may be confounded of biased.

The need to avoid mismatch between the graphics used in instruction and the criterion measures may be exemplified in the studies reported by Dwyer (1972 or 1978). In these studies the degree of realistic detail was varied across nine different treatments: oral/verbal presentation (no visuals), simple line drawing (black and white, b & w), simple line drawing (color), detailed-shaded drawing (b & w), detailed shaded drawing (color), photograph of heart model (b & w), photograph of heart model (color), realistic photograph (b & w), and realistic photograph (color). Several different criterion measures were used to measure student achievement: drawing test, identification test, terminology test, comprehension test, and total criterion test.

In the drawing test, students were provided a list of terms corresponding to the parts of the heart and were asked to draw a diagram of the heart and label the parts of the diagram with the appropriate terms. What type of instructional graphics would most closely match this criterion measure? What kind of diagrams are the students expected to draw? A realistic color representation? If the students are expected to draw a simple line drawing and actually do draw a simple line drawing then it seems reasonable to hypothesize that a different type of representation used in the instructional materials would require the student to do some unnecessary processing.

In the identification test, students are required to identify the numbered parts on a diagram of the heart. But what type of diagram: simple, detailed, model, or realistic? Was the criterion diagram in color or black and white? Naturally, a choice had to be made; whatever the choice, the results could be biased. Dwyer chose a black and white detailed drawing. Would his results have been different if he had chosen a realistic color photograph?

The terminology test required the student to select the appropriate technical term to fill in a blank from a multiple choice list of terms. A sample item is given below:

12. The _____ is the name given to the inside lining of the heart wall.

  a. epicardium
  b. endocardium
  c. pericardium
  d. myocardium
  e. septum

This item does not require the use of graphics. The student is only required to recall verbal information. One could hypothesize that a visual image would help the student recall the correct answer, but the task requirement does not clearly specify the need for a graphic in the instructional materials.

The purpose of the preceding discussion was not to criticize Dwyer's work. On the contrary, Dwyer's study represents a high standard of control among graphics studies. Through the use of several different criterion measures, Dwyer assessed the differential effect of various types of mismatches between the graphics used for instruction and different task requirements. However, even the Dwyer design was not immune to the problems noted, and other researchers have not been quite as careful. The purpose of this discussion is to point out the nature of a difficult methodological problem in research and to stress the need for designing graphics for instruction which match the actual task requirements. If the actual task requires that a trainee identify the "mitral valve" in a real heart, then some practice should be required using as realistic a representation as possible. However, the intial stages of instruction might use a simple line drawing as outlined in the previous section on Classifying.

Many of the guidelines presented in this report are based on instructional design theory and have little empirical support. These guidelines should be considered as hypotheses until validated by future research. The following is a partial list of some issues which need further investication.

1. Will the use of the videodisc (with its capabilities for slow motion, frozen motion, repetition, and stepping through single frames) to demonstrate manual tasks which involve continuous movement be more effective than standard motion sequences or a series of still frames?

2. If the videodisc is more effective for demonstrating continuous movement, which unique characteristic of the videodisc is most powerful.

3. What is the effect of integrating motion sequences and still frames in videodisc instruction?

4. How effective is an instructional strategy for teaching concrete concepts which uses a sequence of graphics that go from simple to more realistic or complex?

5. What are the differential effects or attitude learning of various representations of a human model: in person, pictures, movies, or verbal description?

6. How does visual literacy relate to learning from graphics?

7. How does reading ability interact with learning from text vs. graphics?

8. What abilities are required to interpret tabular and figural displays?

9. What are the differential effects of allowing students to generate graphics (using a computer) in real time vs. allowing them to select from a file of stored graphics?

10. What effect will the resolution of a videodisc picture have on the effectiveness of various types of graphics?

11. What is the added value of dynamic, simulation-like interactions with high visual fidelity, compared to manually accessed visual displays?

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