INSTRUCTIONAL DESIGN: INTEGRATION OF COGNITIVE STYLE AND TECHNICAL CONTENT

Linda J. Brent and Richard P. Brent
Loral Defense Systems
Akron, Ohio

ABSTRACT

Basic research in neuropsychology, learning theory, and cognitive psychology have contributed to knowledge concerning human learning. This research has been applied to the identification of cognitive styles -- defined as an individual's unique method of processing information. Investigations into ways to apply this knowledge through computer-based instruction, the increased use of multimedia technologies, and the integration of artificial intelligence techniques have enhanced occasions for more effective use of computer-based instruction in training applications. While technological advances permit more cost-effective solutions for individualized training, instructional designers may lack adequate techniques for integrating the advances in learning theory and cognitive style with the technology.

The current research literature acknowledges the importance of accounting for the nature of the subject-matter content. Guidelines concerning information presentation in computer-based instruction are needed by instructional designers to accommodate the individual cognitive style of the learner and for the differences in presentation format relative to subject-matter content.

This paper reviews current research, and discusses how instructional designers can integrate the research findings into a paradigm for the effective instructional design of interactive computer-based instruction. The paper describes appropriate design strategies which integrate the application of cognitive style research findings with subject matter content and multimedia capabilities. Specific examples of situations, learning scenarios, and strategies are provided. Directions for future research are also presented.

ABOUT THE AUTHORS

Linda J. Brent is currently the Training Manager for a major AF program, responsible for the integration of training and design requirements for all media developed. Since joining Loral in 1991, she has provided technical leadership for the conduct of two AF schools, curriculum development, and for training/ engineering interface in the final design and production of the training media. Telephone (216) 796-5913

Richard P. Brent is currently responsible for providing technical leadership for engineering process improvement initiatives, especially in systems engineering. Since joining Simulation and Training Systems Engineering in 1993, he has conducted requirements analysis and feasibility studies, defined optimal training system configurations, and developed technical plans for training system development.

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Loral Defense Systems-Akron
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INTRODUCTION

Basic research in the areas of learning theory, memory, neuropsychology (hemisphericity), and cognitive psychology (information processing) has made significant contributions to the body of knowledge concerning how human learning occurs. This knowledge has been applied to the identification of cognitive styles. Cognitive style, initially termed such by Allport (1937), has been described as an individual's typical mode of thinking, problem-solving, perceiving, and remembering (Schwen, Bedner & Hodson, 1979). Ausburn and Ausburn (1978) referred to cognitive style as the psychological dimensions that represent consistencies in an individual's method of acquiring and processing information. Research into ways to apply this knowledge, including technological developments in the use of computer-based interactive instruction and the integration of artificial intelligence techniques can help establish more effective and cost-efficient use of computer-based instruction in a wide variety of training applications.

Instructional designers, however, may not currently have adequate tools and techniques for the development of instructional programs tailored specifically to the individual needs of the learner. In many of the current military training programs, it is assumed that all learners process and store information in the same manner. Recent research suggests that learners absorb, process, and act on information differently (Corno & Snow, 1986; Kogan, 1971; Messick, 1984). For example, some individuals best retain information presented graphically and holistically, whereas others best process information serially, with verbal presentation. Some researchers (Riding & Sadler-Smith, 1992) also acknowledge the importance of taking into account the nature of the technical content or task characteristics when planning the best instructional approach. This can facilitate retention and eventual transfer of training to the job situation.

In addition to the cognitive style characteristics of learners, designers of interactive instruction may not have adequate guidelines for the development of programs which consider the individual cognitive style characteristics of trainees and the most effective mode of presentation for the particular technical content requirements of the material. The problem here lies in the lack of integration of cognitive style factors and the critical content elements which interact and affect learning, retention, and training transfer. If the elements of technical content, cognitive style (both process and representation of information) are consistently considered and applied when designing training, the effectiveness and efficiency of learning can be enhanced.

We shall review the current research in the areas of cognitive style, instructional format and design and provide guidelines for the design of interactive instruction (i.e., interactive courseware, [ICW]).

RESEARCH IN COGNITIVE PSYCHOLOGY

Research in neuropsychology supports the notion of a lateralization of functions in the two hemispheres of the brain, with the right hemisphere predominantly responsible for spatial, holistic, inductive processing and the left hemisphere predominantly responsible for analytic, sequential, and verbal processing (Messick, 1966; Wittrock, 1980). However, more recent research suggests that the cooperative processing of both hemispheres are required for the most efficient synthesis of information.

Hemispheric processing is considered a continuum in which dominance is distributed. The utilization of both hemispheres for certain tasks has been demonstrated, but differential aptitudes in functions may lead to the emphasis of one hemisphere over another in a particular individual's processing mode (Dumas & Morgan, 1975). The results of studies in this area suggest that individuals possess preferred processing modes, but with increased skill or complexity, shared hemispheric processing responsibilities increase (Kolers & Roediger, 1984). There is also evidence to suggest that although information is processed with both hemispheres, individuals tend to process information differently (Kagan, 1965; Pelligrino & Kail, 1982). These differences have been further expanded and addressed in studies which focus on the area known as cognitive style.

Cognitive style has been defined as ". . . self consistent, enduring individual differences in cognitive organization and function." (Ausubel, Novak, & Hanesian, 1978, p. 203). Cognitive style is thought to include all processes used in the processing of information: perception, thought, memory, imagery, and problem solving. These individual cognitive styles appear to be related to hemispheric dominance (Wittrock, 1978) and differences in the modes of processing information (Ausburn & Ausburn, 1978). These differences are not related to which hemisphere is used, only to the degree to which one is used over the other.

Research on cognitive style has presented various models which describe these dichotomous style characteristics. For example, Witkin's (1965) research defined individual differences as related to the characteristics of field independence and field dependence, based on the cognitive perception of information received. Field-independent individuals perceive information analytically and field-dependent individuals perceive globally. Pask and Scott (1972) divide cognitive style into two primary modes according to the processing of information. The first, serialist mode individual, prefers to process information in a progressive, developmental, sequential pattern, while the second, the holistic style individual, prefers processing in a more global perspective. Lohman (1979) also conducted research into the cognitive processing of information based on visual/spatial and verbal inputs.

Some researchers have argued that the dichotomous identification of cognitive style using differing labels are indeed different conceptions of the same style dimensions (Miller, 1987). By combining the results of research on cognitive style, some general characteristics emerge. First, it appears that an individual's cognitive style remains stable over time and across tasks (Riding & Sadler-Smith, 1992). Second, the relationships between various style dimensions appear to hold true, and have similar dichotomous characteristics. For example, holistic processing, inductive reasoning, and field dependence appear to be related to each other and to right-hemispheric processing (Ausburn & Ausburn, 1978; Riding & Cheema, 1991). Third, there is evidence to suggest a relationship between cognitive style and particular learning tasks or modes of information representation (Kozlowski & Bryant, 1977).

Buehner Brent (1987) presented a theoretical framework for grouping the dichotomous cognitive style relationships related to hemispheric processing (Table 1). Riding and Sadler-Smith (1992) have synthesized the research on cognitive style and have grouped cognitive style dimensions into two dichotomous families. These families, the wholist-analytic and the verbal-imagery, address both the representation/perception and the processing of information. The first, the wholist-analytic dimension of style, describes the preferred manner in which individuals cognitively process information, in whole or in parts. The verbal-imagery dimension of style describes the preferred mode of representation of information, by verbal associations, or by the development of mental images, pictures, and associations. An individual's cognitive preference on each dimension is considered independent of one another. For instance, one individual's preferred style may be characteristic of a wholist and an imager, and another individual's style may be characteristic of an analytic and an imager. Individuals fall along the continuum of each style dimension.

When processing information as described in the wholistic-analytic cognitive style dimension, the wholistic thinker appreciates the overall perspective in the total context. In a learning situation, however, the same individual will require assistance in understanding the components which provide the structure for the task. The individual with the analytic style, on the other hand, will initially perceive the components that are to be learned, but will require an overview or more global perspective in order to successfully integrate the respective sections into a whole. This knowledge of an individual's learning style can help to define valuable design criteria for instructional material.

Likewise, the second style dimension of verbal imagery identifies an individual's preferred mode of receiving information. While the imagers learn best

Table 1 - Cognitive Style Dimensions

Left-Hemisphere Dominant	Right-Hemisphere Dominant	Relevant Studies
Field-independence	Field-dependence	(Witkin, Moore, Goodenough, & Cox, 1977)
Reflective	Impulsive	(Kagan, 1965)
Serialist	Holist	(Pask, 1972)
Analytic	Wholist	(Riding & Sadler-Smith, 1992)
Verbal	Visual	(Riding & Sadler-Smith, 1992)

from simple, graphic, pictorial representations or explanations which are easily visualized, verbalizers prefer primarily textual/verbal explanations of the content or graphics laden with detailed verbal information. An understanding of this dimension of cognitive style, by instructional designers, who also consider the way information is represented, can help to design interactive instruction with flexibility in form and format for students.

When a task requires a transformation in processing that is incompatible with a learner's style (for example, purely visual information for a verbal style), the learner may not perform the task successfully. Therefore, instructional designers should consider these styles as a factor when planning instruction, particularly interactive instruction. Ineffective or inefficient learning of technical information may not always be learner-based (e.g., lack of ability). Instead, it may be considered instructional-based, if there was no consideration in the design process for individual cognitive style factors and the nature of the technical content. If one accepts the postulate that cognitive styles and effective learning is an instructional rather than a learner-based issue, it becomes important to devise a means by which instructional modification can be successfully accomplished.

COGNITIVE STYLES AND INSTRUCTIONAL DESIGN

The identification of strategies for presenting information which link cognitive style variables and educational applications has been described by many researchers. Miller (1980), for example, stated that the instructional designer's role is to devise conditions in the learner's external environment which support the learner's internal cognitive process. Others (Frederico & Landis, 1984) state that consideration of cognitive style dimensions can aid individuals in learning information more readily and in retaining/retrieving information more effectively. Grasha (1984), while supporting the need for a match between style and information mode of presentation, also emphasizes that too consistent a match could create a non-motivational attitude in learning, by not encouraging accommodation to variety. The model presented by Brent (1987, 1990) supports the identification of preferred style by the development and use of both hemispheres in processing through the mode of hierarchical processing within cognitive style. The previous discussion concerning the efficient use of processing across the two hemispheres of the brain supports this view as well.

Several cognitive style dimensions appear especially suited for consideration in the design of training programs. For example, in considering the wholistic-analytic style dimension family, the format or structure of the material to be presented could be critical in successful learning. Likewise, in presenting information in a combination of textual and graphic form, an understanding of the verbal-imagery dimension is also relevant. Several research studies have supported the relevance of cognitive style considerations in design. For example, Riding and Douglas (1992) found that for the verbal-imagery cognitive style dimension, the method of information presentation affects learning. While imagers seem to learn best from pictorial representations, verbalizers learn best from verbal presentations. In a study conducted by Brent (1990), the format of instructional material influenced performance, and the most effective presentation format was dependent on the nature of the technical content (e.g., a knowledge, skill, attitude, or decision-making task).

A study conducted by Geiselman and Samet (1982) demonstrated that learning performance was enhanced when subjects were permitted to organize and format information to meet their individual styles. Most technical content tasks will require some differing degree of organization and varying forms of representation, depending on the cognitive style variations among learners across the style dimensions. The format and structure of learning material will affect learners differently. For example, those with the style of verbal-analytic can increase learning when provided with a learning situation emphasizing discrete elements of the content to be learned. The wholist-imager will understand wholes and use diagrams depicting the whole content task. Instructional practice, then, should provide information in a form requiring both the identification of individual elements and the integration into the whole concept to be learned.

Several researchers have found that accommodating learner cognitive style preferences in an instructional presentation can lead to increased achievement and retention of the content material. Napolitano (1986) found that learning was enhanced by using instructional design strategies and formats of information which were congruent with their diagnosed learning styles. Dunn, Deckinger, Withers, and Katzenstein (1990) also found increased achievement among students when information was presented in a form and format sensitive to their cognitive style. McRobbie (1991) found that dimensions of cognitive style were diagnostic predictors for both cognitive organization and knowledge outcome. The findings in his study demonstrate the importance of the cognitive style in the area of science learning. This is based on the learner's knowledge of his/her own style, and the appropriate strategies to employ (e.g., presentation and organization of information) in order to maximize learning.

Considering the research on cognitive style and its interaction with instructional format and content, several general principles emerge which can be applied to instruction and training. These principles are:

1. Individuals vary in the way in which they most effectively process/retain information.

2. The cognitive styles of individuals differ in relation to their hemispheric dominance for information processing.

3. The most efficient, effective learning occurs when processing of information involves use of both hemispheres, and the design of instruction encourages this processing to occur.

4. Instructional design features sensitive to cognitive style variables should consistently include:

   a. Opportunities for the learner to adjust aspects of the instructional environment (e.g., organization of the content, perspective, etc.).

   b. A combination of verbal and spatial information, closely related to one another.

   c. A flexible instructional organization, which includes an overview in verbal and spatial format, and opportunities for review and reinforcement.

   d. Opportunities for the learner to apply new information to a variety of learning situations.

5. Instruction should remain consistent with an individual's cognitive style.

Using these principles in the design of instruction may create unique problems for the development of instructor-led training. However, the increased use of computer-based interactive instruction (ICW) in training programs provides tremendous opportunities to individualize training which is sensitive to cognitive style dimensions. Interactive instruction provides opportunities for graphics, animation, video, and sound, along with the capability to branch and provide student feedback in a variety of ways. As discussed in AF Handbook 36-2235, (Department of the Air Force, 1993) on the instructional design process, interactive instruction has the capability to provide flexibility for the learner by presenting information in visual or verbal formats, with student interaction, error response capability, and animation.

A significant trend in the military is the increased use of computer-based interactive instruction. In many such programs to date, however, the learner must adapt to the format of the instruction provided. The capabilities of the computer-based system are not used to take advantage of the flexibility in presentation. The exciting potential of this media, however, is in its capability to present individualized instruction, designed to be modifiable to meet the needs of all learners in a variety of learner settings and situations. Additionally, the capabilities of new processing and development systems like Hypercard create even more opportunity for flexibility, especially where learning situations are not purely linear in nature. The key to effective use of this media to maximize learning is to develop instruction which appropriately uses graphics, text, animation, and so forth, which is based on cognitive style dimensions and on the nature of the content.

IMPLICATIONS OF RESEARCH ON INTERACTIVE INSTRUCTIONAL DESIGN

As discussed, current research supports the integration of cognitive styles and technical content. With the flexibility provided by interactive computer-based instruction, effective and efficient learning can be enhanced. General principles emerging from the research in this area can serve as general guidelines in the design of learner-based training. These guidelines are as follows:

1. Cognitive style research useful to instructional designers can be synthesized into two dichotomous style dimension families: wholist-analytic, and verbal-imagery. These two dimensions describe the way individuals process/organize information and the way in which they represent the information.

   Design Principle for Wholist-Analytic Dimension: Provide opportunities for learners to format information in a variety of organizational formats. For example, provide an advanced organizer at the beginning of a lesson to define the overall lesson purpose, its components, and the way in which the portions of technical content within the lesson fit together. Permit opportunities for the learner to access this information throughout the lesson in order to put the detailed information being presented in a more global context.

   Design Principle for Verbal-Imagery Dimension: Provide information in at least two forms, verbally (in text) and visually (in simple pictures/diagrams). For example, present the advanced organizer described above both verbally (in text) and visually (in a simple hierarchical diagram). Permit the learner flexibility to access the preferred format of information throughout the lesson.

2. Cognitive styles are resistant to change. As such, the instructional designers should not expect the learner to adapt his individual style to the content and format of instruction. Instead, the instructional format should be designed to maximize learning across style dimensions.

   Design Principle for Wholist-Analytic Dimension: Provide cues to the learner throughout the lesson which relate the content presented as part of the entire lesson material. For example, if the purpose of the lesson is to define a series of menu screens on an aircraft multi-function display (MFD), design the lesson to permit the learner to return to a pictorial representation of the overall menu screen architecture.

   Design Principle for Verbal-Imagery Dimension: Provide both verbal and visual information whenever possible to instruct the technical content. In the case of the MFD example, use a windowing capability in the lesson to provide verbal information and direction to the learner while maintaining the graphic image of the MFD on the screen for reference and visual matching to the verbal information.

3. Although individuals tend to demonstrate preference for a given cognitive style, instruction should provide variety to challenge and integrate both hemispheres of the brain, enabling cooperation among style characteristics and maximizing the efficiency of learning.

   Design Principle for Wholist-Analytic Dimension: Use techniques such as color, highlighting, and windowing to define the learner focus on a given portion of the technical content. For example, use color coding of information to guide the learner in parsing the technical content into appropriate categories as to the way the information of the moment fits into the overall content being taught.

   Design Principle for Verbal-Imagery Dimension: Use a variety of color, animation, graphics and video inputs throughout the course of the lesson as appropriate for describing the technical content. For example, to demonstrate the loadmaster tie-down procedures of certain cargo, provide a written checklist, along with short video segments, to describe the steps in the checklist procedures.

4. While verbalizers can process detailed, complex information without the use of visual images or organizers, imagers process information best when it is presented in simple, concrete diagrams and visual images.

   Design Principle for Wholist-Analytic Dimension: Use the windowing capability of the technology to allow learner choice in defining the information needed at any point in time. The learner should be able to choose the information present at a given time rather than having a multitude of technical content information on the screen at any one time, which would require cognitive sorting and organization of unnecessary information.

   Design Principle for Verbal-Imagery Dimension: Provide information on the screen using the simplest visual format possible. Use simple graphics, animation and video to visually illustrate a technical concept, without making the presentation confusing by overloading the screen with superfluous information. For example, a simple line drawing may better demonstrate the concept of terrain following than a complex motion video of the out-the-window view from a plane engaged in terrain following. The complex video could prevent the learner from attending to critical elements in the description.

5. Provide flexibility for the learner to progress through a lesson by providing opportunities to individualize the instruction to match the cognitive style characteristics of the learner.

   Design Principle for Wholist-Analytic Dimension: Permit the learner to move freely back and forth through the lesson, with an ability to access frequently used concepts through a help menu system. For example, permit the learner to return to the overall advanced organizer of the lesson as required to visualize how the content being displayed at the moment fits into the overall concept being taught.

   Design Principle for Verbal-Imagery Dimension: At key instructional points, permit the learner to access a second format by which to demonstrate the information being taught. For example, if the technical content describes the characteristics of an aircraft system, provide opportunities for the learner to access wire diagrams, online which can enhance understanding of the operation of the system. For example, the use of Hypercard techniques provides the learner with the capability to explore technical content in this associative, nonlinear manner. It enables learners to make their own individual choices and follow their own learning paths.

6. Design the interactive instruction according to the type of information presented. Staver (1984) and Trafton (1984) recognized that learning was most effective when considerations of the type of technical content were made. This perspective is also supported by Brent's (1990) research where two content areas, particularly skills and decision-making, were impacted by instructional format, namely, visual/spatial information combined with minimal text.

   Design Principle for Wholist-Analytic Dimension: Use a visual web to define relationships among components of information. This technique provides structure for the technical content by providing a visual image of the interrelationships of the concepts.

   Design Principle for Verbal-Imagery Dimension: Design interactive computer-based instruction to provide opportunities for the learner to use a combination of verbal and visual information. The most effective presentation order for information is either to present them in synchrony, or present the visual before the verbal (Baggett & Ehrenfeucht, 1983). Further, when both are presented in synchrony, it may be advantageous to place visual information to the left of the verbal information to maximize processing by the right hemisphere of the brain (Wickens, 1984).

Today's economic climate dictates that training programs must be designed in a cost-effective manner. Using multimedia technology and interactive computer-based design techniques, instructional designers can consider cognitive style characteristics and instructional format considerations. If these methods are employed to enhance cooperative process, learners may obtain long-term retention and transfer of information benefits. Use of these design principles, over time, could reduce the length of training, improve its effectiveness, and therefore reduce its cost.

Future research should continue to focus on the use of interactive technologies to design instruction which integrate cognitive style and technical content dimensions. First, research should continue efforts to refine the critical elements of cognitive style. Research into the nature of these characteristics and their relevance to adaptive training models should be conducted.

Second, research should focus on the development of a computer-based cognitive style assessment tool which is based on the nature of content to be presented during the training course. This instrument could assess the most salient factors for effective performance in training tasks in the content areas of knowledge, skill, attitude, and decision-making. Research to date has identified several possible factors important to consider in the development of training programs (e.g., presentation format, cognitive style). With additional research, it may be possible to develop either a cross-content or content-dependent instrument to assess learner characteristics before training begins. Since computer-based training offers opportunities for the development of adaptive training programs, these programs could then be adapted to meet individual training needs.

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