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ABSTRACT

This study was designed as a first attempt to study the relationship of learning style, perception, and performance to computer based instruction (CBI). First the relationship of two dimensions of cognitive styles, field independence-field dependence (FI-FD) and preferred perceptual mode (verbal-visual) was studied. Second, the main and interactive effects of the two dimensions of cognitive style on the performance of individuals on a concept-learning task were studied in the context of two presentation formats in a CBI lesson: text-only and text-plus-animated graphics. The cognitive styles of 192 undergraduates were determined. Independent variables were the two dimensions of cognitive style and the presentation format of the lesson. The dependent variable was a 21-item multiple-choice posttest. The data analysis indicated that the two dimensions of cognitive style were independent. A multiple regression analysis with the posttest as the criterion and the three independent variables and the two-way interactions between them as predictors provided several conclusions. Individuals given a lesson format that matched their verbal/visual preference did not seem to improve their performance. The more FI individuals did not differ significantly from their less FI peers in achievement. (Contains 108 references.) (SLD)

EFFECTS OF COGNITIVE STYLE AND VERBAL AND VISUAL PRESENTATION MODES ON CONCEPT LEARNING IN CBI

by
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Running Head: COGNITIVE STYLE AND CBI PRESENTATION MODES

Abstract

Educational research has demonstrated that the quality of learning can be enhanced when the instructional design/teaching strategy is matched to individual learning style (National Association of Secondary School Principles, 1979). However, very little research is available relating individual differences manifested in cognitive learning styles to instructional design or computer-based presentation (Jonassen, 1988; Post, 1987). This study was designed as a first step in an attempt to uncover the relationship of learning style, perception, and performance. The study consisted of a two-step process. First, it investigated the relationship of two dimensions of cognitive styles, Field Independence-Field Dependence (FI-FD) and preferred perceptual mode (Verbal-Visual). Second, it studied the main and interactive effects of the two dimensions of cognitive style on the performance of individuals on a concept learning task in the context of two presentation formats within a CBI lesson: Text-Only and Text-plus-Animated Graphics.

The cognitive style of 192 undergraduate volunteer subjects was determined using the Group Embedded Figures Test (GEFT) and Verbalizer-Visualizer Questionnaire (VVQ). The independent variables in the study were the two dimensions of cognitive style and the presentation format of the lesson. The dependent variable was a 21-item, multiple choice posttest.

The data analysis indicated that the two dimensions of cognitive style were independent. A multiple regression analysis with the posttest as the criterion and the three independent variables and the two-way interactions between then as predictors provided several conclusions. Individuals presented with a lesson format that matched their Verbal/Visual preference did not seem to improve their performance. The more FI individuals did not differ significantly from their less FI peers in achievement.

THEORETICAL FRAMEWORK

The importance of recognizing the learner as an individual and the necessity of addressing the needs of the individual has not escaped educators. Individual differences are evident in the way each learner acquires, assimilates, processes, and manipulates lesson information (Cattell, 1963; Skinner, 1954; Spearman, 1904). In spite of considerable dialog, there has been substantial discontinuity between the theory and practice in identifying and meeting the needs of the individual.

Learner characteristics like prior knowledge, measured ability, aptitudes have been studied to varying degrees in terms of their effects on learning. However, research in an area of individual difference labeled learning styles has been lacking from the perspective of its effects on CBI design and delivery. Suffering from confusion in definitions, and weakness in reliability and validity of measurement (Curry, 1991), learning style as a valid "person" variable has been often overlooked. An additional stumbling block in the consideration of learning styles as an indicator of individual difference has been the debate on its relationship with ability, aptitudes and strategy. However, several recent studies (Manfredo, 1987; Riding & Sadler-Smith, 1992) have provided convincing arguments against such a relationship.

Learning/Cognitive Style Research

Learning style differences between individuals have been researched under a variety of labels used interchangeably such as "cognitive style," "learning style," "cognitive maps," and "learning modalities." Though the interest in learning styles can be traced back to pre-Christian Greece (Fernald, 1943), most of the research available in the area of learning/cognitive style dates back to the late 1950's through the early 1970's (Dunn, Dunn, & Price, 1975; Frostig & Horne, 1964; Witkin, 1950).

The main stumbling block in learning/cognitive style research has been the overwhelming number of labels that have been coined by researchers. The failure of theorists and researchers to acknowledge the existence of styles other than those that they had identified has also been a problem (Lewis, 1976). One unfortunate consequence was that various research results were not consolidated (Riding and Cheema, 1991).

In recent times, the definition of learning styles has been revamped considerably and has been given a more general interpretation. Moving away from the previous, seeming preoccupation of determining perceptual mode that would best improve learning, attempts have been made to consolidate the research and the terminology. The present connotation of learning style is broader than earlier views though it still subsumes the concept of cognitive style. It is a more general term referring to the style difference among individuals. Though some researchers still believe that cognitive style and learning style are the same construct (Entwistle, 1981), most consider the two to be different (Curry, 1983; Das, 1988; Keefe, 1982). Keefe (1982) considers learning style as a tri-domain construct consisting of the cognitive, affective, and physiological domains. An alternate model for grouping learning style measures developed by Curry (1983) parallels the effort of Keefe (1982).

Learning style has been seen as a multi-element construct and an individual is considered to have one or the other element in one's style. Learning style is not considered to be bipolar and therefore, not to seen as an "either-or" construct. On the other hand, cognitive style has been seen as a bipolar dimension and the term has been reserved for theoretical descriptions. Cognitive style has been seen to be a construct containing one element of style with two polar extremes, for example, either field dependent or field independent.

In the past decade, learning style research has been directed towards the goal of identifying an individual's preference and then teaching in ways that accommodate it. The advantage of such an approach had been corroborated by research (Carruthers & Young, 1980; Dunn, 1981) showing that student's attitudes improve when instruction matches their learning strengths. Carbo, Dunn, and Dunn (1986, pp. 25-29) list several studies conducted in the 1980's with populations varying from first graders to college students that indicate significant improvements in learning when instruction caters to different learning styles.

In more recent times, the interest in learning styles as a viable issue in education has been strengthened by brain research (Sonnier, 1985). This research indicates the existence of a serial/verbal versus global/visual mode of processing information based on hemispheric considerations and supports neurological differences in information processing styles and capabilities of humans (McCarthy, 1990). The interest shown by the National Association of Secondary School Principals in brain research and in the development of the Learning Styles Profile (LSP) (Keefe, 1988; Sinatra, 1984), shows the growing commitment to understanding learning styles and designing learning environments to support students with different styles.

The dominant research interest in recent times has been in the cognitive dimensions of learning styles, known as cognitive styles which have been defined to be stable, relatively enduring consistencies in the manner or form of cognition (Keefe, 1982). A multitude of cognitive styles have been identified (Messick, 1976, 1984; Riding & Cheema, 1991). The lack of substantial correlation between different measures of cognitive style has led to the hypothesis that cognitive style is a multidimensional construct. However, the failure to consolidate research by researchers in the past has resulted in the argument shared by many (Miller, 1987; Riding & Buckle, 1990) that most of the style labels represent the same style dimension. Also, several criticisms have been voiced regarding the measures used in the existing research (Brumby, 1982).

Of the multitude of cognitive style dimensions listed by researchers, two style dimensions -- field independence-field dependence (FI-FD) and preferred perceptual mode (verbal-visual) -- have been identified as being most worthwhile for further research (Green, 1985; Riding & Cheema, 1991). This has been based on the amount of research conducted using the style dimensions since its conception, and its practical value and applicability for cognitive tasks and classroom teaching. Based on the various measures used, Riding & Dyer (1983) concluded that they are the most conceptually comprehensive and potentially independent dimensions of cognitive style.

Field Independence-Field Dependence

Individuals classified as field independent (FI) are able to overcome the embedding context of a field and tend to perceive certain parts of the field as discrete from the surroundings. Individuals classified as field dependent (FD) are guided by the field as a whole and are influenced by the field factors and complexity of the surrounding visual area. They depend on external cues to make judgments (Maccoby & Jacklin, 1974; Witkin & Goodenough, 1981). Thus, FI-FD is measured along a continuum from an analytic to a global way of experiencing the environment.

The identification of subjects as FI-FD was first developed by Witkin (1950) and emerged as a cognitive style based on his work (Witkin, 1962, 1978). It is perhaps the most thoroughly researched cognitive style dimension (Keefe, 1979; Worthley, 1987). Several measures for this dimension of cognitive style are available. Some of these are Body Adjustment Test, Rod and Frame Test (RFT), and Embedded Figures Test (EFT and GEFT).

This dimension of cognitive style is independent and different from intelligence or creativity (Hashway & Duke, 1991). Witkin and Moore (1974) showed that the categorization had significant implications on instruction and learning. Research studies indicate several differentiating characteristics of FI-FD individuals. These studies have involved both male and female subjects and several different age groups. Some of the research findings relevant to discussions in this study are listed here.

1. FI individuals prefer to compete and gain individual recognition. They are task oriented and prefer learning that emphasizes detail to concepts (Berger & Goldberger, 1979).

2. FIs are better able at focusing attention on relevant aspects of the field and ouperform FDs on most tasks and measures especially in situations where unambiguous task-relevant information, appropriate social feedback, or external reinforcement are limited (Goodenough, 1976; Witkin, Moore, Goodenough & Cox, 1977).
3. Evidence linking field dependence to deficits in attention, encoding, and long-term memory processes has been established in several studies concerned with information-processing characteris' cs of FI and FD individuals (Davis and Cochran, 1989).
4. Studies involving recall of learned material have led to the conclusion that FD persons differ from FIs as a result of inefficient use of working memory by the FDs under increased processing demands (Reardon, Jolly, McKinney, and Forducey, 1982).
5. Spiro and Tirre (1980) found that FD students were unable to utilize schemata to aid in the recall and retrieval of information. They concluded that FD individuals were unable to impose a previously acquired, applicable schema on a new piece of information -- that FDs were more "text-bound" then FI individuals.
6. FI-FD has also been found to correlate to visualization ability and analytic ability. FIs have been shown to be better at restructuring and organizing visual/spatial information than their FD counterparts (Couch & Moore, 1992; Joseph, 1987).
7. FIs significantly outperform FD peers even under instructional treatments designed to facilitate FD learners' approach to material (Davis, 1991).

Performance differences between FI and FD individuals has been investigated in several different curriculum areas like math (Garn : & Cole, 1986), science (Mitchell & Lawson, 1988), and reading (Davis, 1987). Within these areas, the pattern of results have been consistent in showing an achievement advantage favoring FI students.

Group Embedded Figures Test. The Group Embedded Figures Test (GEFT) developed by Witkin and his associates at Brooklyn College has been used widely as a measure of FI-FD. Since its conception its utility as a valid measure has been greatly enhanced by several normative studies available. Studies have established adequate internal consistency (Goldstein & Blackman, 1978; Panek, Funk, & Nelson, 1980) and adequate values for the reliability and validity (Cummings & Murray, 1987; Kepner & Neimark, 1984). Carter and Loo (1980) report no significant sex differences for this cognitive dimension. Some of the failures in confirming the reliability and validity (Lis & Powers, 1979; Renna & Zenhausern, 1976) of GEFT has been attributed to the psychometric problems of group instruments.

Preferred Perceptual Mode (Verbal-Visual)

Verbal versus visual measures (perceptual mode) of cognitive style differentiates between people using sequential methods of processing information (verbal) versus parallel processing (visual). Not surprisingly, individuals classified as visual are shown to be better than their verbal counterparts in the recall of highly visual material.

Some controversies exist regarding the nature of perceptual mode. While F. B. Ausburn (1979) and others (L. J. Ausburn, 1979; Messick, 1976, 1984; Riding & Cheema, 1991) indicated that perceptual mode constitutes a cognitive style, there are researchers (Dunn, Dunn, & Price, 1979) who have indicated that it is more physiological in nature.

Research has ascertained that imagers learn best from pictorial presentation while verbalizers are superior when the mode of presentation of information is textual (Riding & Buckle, 1990; Riding, Buckle, Thompson, & Hagger, 1989). When the content of the presentation is concrete and allows for visualization, imagers have been found to be more successful while the verbalizers do better when the content has semantically and acoustically complex details (Riding & Calvey, 1981).

An issue that needs to be studied is the possible relation of the verbal-visual perceptual preference and the FI-FD cognitive dimension. According to F. B. Ausburn (1979), FI-FD can independently predict perceptual mode and is the best predictor of perceptual mode. However, Manfredo (1987) failed to detect any significant correlation between FI-FD and perceptual mode.

Assuming that FI-FD and the verbal-visual dimensions of cognitive style are independent, each has a unique implication for learning and teaching. The fact that verbalizers prefer and perform best on verbal tasks while imagers on concrete, descriptive, and imaginal ones indicates the necessity of matching the material and mode of presentation to this learning style dimension.

Although several measures can be used to assess imagery, only three exist for assessing the verbal-visual cognitive dimension. These are the Individual Difference Questionnaire (Paivio, 1971), Verbalizer-Visualizer Questionnaire (Richardson, 1977), and Verbal-imagery Cognitive Style (Riding & Taylor, 1976). The Verbalizer-Visualizer Questionnaire (VVQ) is perhaps the easiest to administer in a group situation.

Verbalizer-Visualizer Questionnaire. Alan Richardson's (1977) Verbalizer-Visualizer Questionaire (VVQ) is one of the commonly used tests for differentiating between individuals' preference between visual or verbal perceptual modalities. Since its creation, however, the test has been used little in instructional research.

VVQ has been reported to be sufficiently reliable for research purposes (Richardson, 1977; Warren & Good, 1979). High test-retest reliabilities have been reported for both males and females (Richardson, 1977; Spoltore and Smock, 1983). The stability of this test has been reported in the research by Stevens, Rapp, Pfost, and Johnson (1983). Though doubt has been cast regarding the construct validity of the VVQ based on its failure to exhibit a proper level of internal consistency (Boswell & Pickett, 1991), Green and Schroeder (1990) concluded that the VVQ had an adequate internal consistency reliability for use in research. However, the validity of the visual style measured by the VVQ has been determined to be doubtful since it did not relate to visual ability (Green & Schroeder, 1990).

Research in Visualization

The way people construct mental images has been an area of interest for researchers for many years. In the past, educational researchers have shown a modest interest in visualization and its role in learning and teaching. The increased interest in recent times can be attributed to the attempts by instructional designers to apply what has been learned about visual thinking to instructional design. This interest can be attributed to present advances in many areas, such as the study of imagery, visualization, cognitive style, neurophysiology, phenomenology, visual literacy, and symbol systems. Additionally, recent and continued advances of computers to produce high quality graphics and animation combined with its increased use in teaching and training has helped to rekindle interest in educational visualization.

Though the initial research into the advantages of visualization in learning was based on subjective reporting, there has been a large number of laboratory studies demonstrating how imagery affects learning. All this research provided convincing initial evidence of the important role of imagery in learning. Imagery studies support the use of illustrations in textbooks and other printed material. Additionally, support for the use of visuals as an aid to learning comes from several theoretical frameworks. Allan Paivio's dual-coding theory has been instrumental in indicating that imagery mediation is a powerful facilitator of learning and memory. Given that the computer is now a relatively common delivery platform for instruction, the opportunity exists to develop a wide range of visually rich learning environments, such as animated illustrations as well as interactive simulations.

Due to limitations of space and time, only some of the successes of visualization research have been addressed in this section. Early research (Shepard, 1967) as well as more recent studies (Purnell & Solman, 1992) have found that illustrations lead to superior comprehension compared to text. The power of pictorial presentation over verbal presentation was shown in a research study conducted by Biron and McKelvie (1984). A study conducted by Moore, Chan, and Au (1993) with 183 high school students found that subjects who used textual aids provided in a computer-based presentation, especially diagrams, did much better on recall performance. Research by Guttman, Levin, and Pressley (1977) suggests the importance of considering the age factor in the ability to utilize pictorial information.

Levin, Anglin, and Carney (1987) have developed a set of explicit ground rules which could be useful for instructional designers. These rules underscore the necessity of pictures being congruent to the accompanying information (such as the text) and also that the pictures should clearly represent the content. Mayer and Gallini (1990) conclude that illustrations are particularly effective if the text is understandable, illustrations are measured in terms of learner understanding, illustrations are used to explain, and the material is new to the subjects.

An issue in pictoral research has been the quality of the pictures. Dwyer's (1978, 1987) series of studies with adults concerning the realism of pictures indicated that the learners ignored the visuals or attended to inappropriate information in the visuals when provided with too much information (i.e., highly realistic) or too little time.

Most of the research in visualization has concentrated on static visuals and there exists very little empirical data in the literature for the use of animated visuals. This does not indicate a lack of interest among researchers but is a result of deficiencies in the technology prior to the 1980's.

Though animated visuals are different from static visuals and graphics, the issues concerning its applications in education are quite similar. A casual review of educational software indicates an extensive presence of animation. Powerful authoring tools available to novice software developers has led to a proliferation of animation sequences purely for cosmetic purposes. Surprisingly, little research data available on the effectiveness of animation as a valid instructional tool is available.

Rieber (1993) has reviewed the research available in the use of animation for instruction. Rieber (1989) has attributed the failure of several animation studies in providing support for its use as an instructional tool to a variety of possible sources of confounding, such as poor instructional design of the materials, issues related to prior knowledge and maturation. Two studies by Mayer and Anderson (1991, 1992) have investigated the need for narrations accompanying animation. Both of these studies support the dual-coding hypothesis and assert the need for a connection between pictures and words during presentation. Results of the research show that subjects who were presented with simultaneous narration and animation did better at problem solving than those who were presented narration before animation. Moreover, subjects who received both animation and narration did better than those who received just the narration or just the animation.

In using static or animated graphics in CBI, one should be aware that graphics do not always serve their intended purpose and inappropriate uses may be detrimental to learning (Rieber, 1993). Rieber (1990) concludes that the use of animation in presentations challenges the visualization skills of individuals. If used correctly, animation in presentations could result in increased attention, motivation, and learning (Rieber, 1990). However, several studies of animations in CBI (Rieber, 1989; Rieber, 1991) show that there is no singular "correct" way for using animation.

In summary, research on the use of graphics in learning has been difficult to interpret and understand. Though limitations exist, enough research on graphics has been produced to show some positive results, though not enough to develop a comprehensive framework for its role in instruction. Research shows tendency for pictures to be remembered better than words. Evidence exists relating picture types to different objectives for better learning. The effect of pictures on cognitive processes have also been investigated. However, all this has not helped in developing a coherent strategy for instructional use. It is evident that instructional practitioners know very little about visualization (Rieber, 1993).

Instructional Design

The design of instruction is a multi-phase, multi-faceted process aimed at aiding the learning of the individual based on the knowledge of how individuals learn. Perhaps the most important of all the questions that could be asked in the design of instruction is about the condition under which learning occurs. The act of learning is facilitated by both external and internal events. The external events are those that are manipulated by an outside agent (e.g., textbook, teacher, stimulus from environment). The internal events are the psychological events wherein information is transformed from one form to another. The whole basis of instructional design is rooted in being able to identify external and internal conditions that effect learning, and in attempting to manipulate these conditions, for effective instruction.

What we know about instructional design today is the result of a confluence of ideas and concepts developed over a period of several decades. Since the 70's, the approach to the design of instruction and learning has shifted from a previously behavioral to a more cognitive approach. Whereas the behavioral approach emphasized the use of reinforcement in instruction to help individuals maintain task persistence, the cognitive approach focuses on what individuals are doing or thinking while they are engaged in a task. In moving away from a behavioral approach and embracing the cognitive approach, the argument is that instruction is mediated by thought processes and furthermore, the recognition of the role of cognition on learning (Clark, 1984; Di Vesta & Rieber, 1987).

Instructional technology that is computer-based has hastened the use of cognitive psychology concepts in instructional design (Shrock, 1991). Computers offer an ideal tool for individualized instruction, especially when the dimension of cognitive style is considered. The cognitive view of instructional design has various implications in educational research. Cognitive science has changed the approach to both the analysis of information-to-be-learned, and the means of evaluating learners. Whereas previous approaches based on behaviorism were predisposed towards identifying the external structure of the information independent of how it is stored in memory, the cognitive approach puts more emphasis on the organization of information within a knowledge base so as to make it accessible for higher order cognitive activities. The emphasis is on the qualitative aspects of how knowledge is organized rather than merely the quantity of information that is stored. The cognitive approach to instructional design has also changed the focus of learner evaluation by taking on a more diagnostic function. Thus, diagnosing learner needs has become a primary focus of empirical research (Tennyson & Christensen, 1988).

Cognitive styles research has important repercussions for instructional design. When a learner's manner of transforming stimuli prevents the successful performance of a task, some external assistance has to be given (e.g., supplantation method proposed by Ausburn and Ausburn (1978)). This could be done by altering or adapting the cognitive style when it is an obstacle to learning. However, since cognitive styles resist change (and may be required for success in some other task), a more appropriate approach would be to design the instruction to help the individual deal with the task causing difficulty. All existing theories and principles in instructional design suffer from too much generality and lack the specifics of interactions between learners, learning tasks, and instructional treatments.

Though cognitive styles have been related to many other learning abilities and activities, there is very little research relating it to instructional design (Ausburn & Ausburn, 1978). Several hundred studies have been conducted on cognitive styles, relating them to other styles, learner characteristics, and performance in particular subject areas. The few studies that do exist relating cognitive styles to instructional treatment have suffered from "being weak in explicating specific theoretical binding among information processing traits of individuals with particular styles, information processing requirements of a particular task, and the accommodating mediation of the treatment" (Smith, 1984, p. 7).

Use of Computers – Computer-Based Instruction

In education, computers have offered a new promise. Several visionaries, researchers, and philosophers have offered numerous possible effects of computer use. Salomon (1984) notes that the road between the promise and realization of computers in education is very long. In order to make the promise a reality, educators and researchers need to integrate this powerful tool with proven, traditional methods of instruction. The increasing availability of microcomputers combined with decreasing costs make the incorporation of computers in the educational curricula very viable.

There are several advantages to computer-based instruction (CBI), not the least of which is its cost effectiveness as a tool. It offers the possibility of truly individualized instruction, ease in data management, and helping the learner to attain the desired competence (Alberta Education, 1987; Rich, 1991). Perhaps the greatest advantage that computers have to offer is the unprecedented graphical power for all designers. Graphical tools increase the productivity of traditional print-based materials and animation packages increase the productivity of traditional video-based materials. Tools providing learners with "real-time" and "on-line" interaction offer new environments for learning (Rieber, 1993).

Research in CBI has been dominated by studies comparing computer-assisted instruction to traditional instruction. In the last two decades several syntheses conducted on the effectiveness of computer-based instruction has covered all levels of instruction. Most of the early computer uses were mainly limited to drill and practice and tutorials. The effectiveness of computer-based instruction has been judged based on improved test scores as well as better attitudes, reduced learning times, higher course completion rates, and increased retention duration. Kulik and Kulik (1987) found in their synthesis of 199 studies of CBI that students learned more with computer assistance, instructional time was reduced, and students liked instruction more. Based on their synthesis of reviews on previous CAI literature, Niemiec and Walburg (1987) concluded that though most of the studies showed that CBI held significant advantages over traditional instruction, the effectiveness was not enough to warrant the cost of the technology.

What we know of the effectiveness of CBI is thus based on a comparative analysis with traditional classroom instruction and is confounded by the fact that CBI was in addition to the existing classroom instruction. Studies in which CBI was used as a supplement for traditional instruction have had mixed results. Lack of information of the study conditions and statistics have made it impossible to prescribe ground rules for effective CBI. Comparative analyses available comparing different CBI is worthless for future research since they compare CBIs with different instructional contents, objectives, presentation formats, and learning outcomes.

Future research in effectiveness of CBI should be more directed and should tie into the theories of learning. Research is needed into pacing learners, feedback strategies, and the several opportunities that computer affords in understanding the complexities of human learning based on individual differences.

Computers in the Research of Cognitive Styles.. Microcomputer technology has a lot to offer in the research of cognitive styles. Computers lend themselves well to the concept of individualization and its management. The major intent of individualization is the matching of individuals to alternative treatments for efficient learning. Cognitive styles are a form of individual difference and its research and application in the classroom could be enhanced by utilizing the power of computers. Research has indicated that individualization can be maximized by using information about cognitive styles sometimes also referred to as learning styles (Dunn & Dunn, 1979; Keefe, 1982; Whitley, 1982).

There have been many reported uses of computers in the cognitive style research in the past (Whitley, 1982). However, these uses have not included the monitoring and evaluation of student performance on alternative treatments as also formulating data into reports for students and teachers. Computers have been used more for analyzing the learning style information.

Individualization based on cognitive styles requires systematic analysis, complex decision making, and refined matching of style to alternative treatments. Without the aid of computer technology this task would require a prohibitive amount of man-hours and would be inefficient. The use of computers offers a practical and cost effective approach to maximizing student learning and motivation (McCombs & Bruce, 1984).

Summary

For instructional design, the variation in cognitive style implies much more than the difference in skill or ability between individuals. There seems to be both a qualitative as well as a quantitative difference in the way that each individual learns. Cognitive styles have been defined to account for these differences. The effort of researchers studying instructional implications of learning styles has been hampered by a lack of consensus on the knowledge bases and heuristics that could be used in the selection of a specific instructional strategy. Thus, despite advances in computer-based technologies to design courseware capable of adapting to the learner attributes in real-time, little guidance from research is available. The little research that does exist is insufficient to guide instructional design.

Studying effectiveness of different instructional methods in terms of the different learning styles has become more possible with the growing use of the computer for teaching and learning. The computer, with its unprecedented graphical power, has become a tool of choice for teaching and learning. Traditional print-based material can now be presented in a variety of visual presentations (using e.g., animation), and "real-time" interactive simulations constructed with easy to use graphic and authoring tools. However, little of what we know of the value of graphics and visuals in learning has been based on research from computer applications. It is necessary to understand that the use of visuals and graphics is not always appropriate and inappropriate uses could very well thwart well-intentioned instructional design. There is, therefore, a need to guide the instructional design of these potentially powerful learning environments, especially as authoring tools increase in number, sophistication, and ease-of-use.

Exploiting the potential of visualization techniques to enhance learning is a very valid mission. An important concern is how appropriate or inappropriate matching of an individual's learning style with various visually-based presentations either enhances or detracts from the learning experience. Field dependent persons, with their global perceptions, may find it difficult to solve certain classes of problems where the solution requires them to extract a certain critical element out of the context in which it is presented and, subsequently, to restructure the problem material with this element used in a different context. Similarly, verbalizers may find highly realistic, visually-based presentations (i.e., high fidelity) to be too complex.

RESEARCH OBJECTIVE AND METHODOLOGY

The main objective of this research was to study the main and interactive effects of the two cognitive style dimensions on the performance of individuals on a concept learning task. The concepts are delivered using two formats of a CBI lesson: Text only and Text plus Animated Graphics.

Method

Subjects

Subjects consisted of 192 upper-class undergraduate college students (167 female and 25 male). Students were enrolled in undergraduate education courses at Texas A&M University.

Participating students represented a wide range of majors predominantly from Liberal Arts and Education. Participation was voluntary and subject to personal consent. To ensure maximum cooperation and participation, and to reduce attrition due to withdrawal (a choice given to participants), incentives in form of extra credit or "bonus" were offered in one of the education courses that the subject was enrolled.

Materials

An original computer-based lesson was designed and developed for use in this study. The lesson described the concepts of velocity and acceleration in one-dimensional space. The lesson was self-paced.

The two presentation formats -- Text-Only and Text-plus-Animated-Graphics -- used in this study contained the same lesson content. The Text-Only format consisted of 41 individual frames of text presented in a linear fashion. The screen was divided into two zones and the text appeared, typically, in the top zone. After each frame was presented, the subject was instructed to go to the next frame by clicking the mouse on a special area reserved at the bottom of the screen.

In the Text-plus-Animated-Graphics condition, animated graphics were added to the text. The top zone of the screen presented the same exact text as provided in the Text-Only condition. In addition, the lower zone of the screen presented this information in graphic form using animation. During the animated sequence presentation, the subject could not use the mouse or the keyboard to interact with the computer. All through the animated presentation, the textual material remained on the screen and was available to the subject for reference.

The animated graphic was usually of a car moving across the screen in variety of ways corresponding to the motion concepts being discussed. A clock was shown ticking continuously to represent the passage of time and whenever necessary a digital readout of the time was included on the screen. A digital readout of distance, speed, velocity, and acceleration was included when necessary, as a simulation of real-time changes taking place during the car's motion. Any mathematical equations presented previously in the text, were shown in terms of changing conditions during the animation.

Two cognitive style indicators -- Group Embedded Figures Test (GEFT) and Verbalizer-Visualizer Questionnaire (VVQ) -- were also used. The GEFT was used to identify the increasing Field Independence (or decreasing Field Dependence) of individuals while the VVQ was used to determine the degree of preference for visual modality (to identify whether an individual is more or less visual)

Dependent Measures

Performance (as measured by student posttest scores) was the data source studied in this research. The posttest consisted of 21 items in a multiple-choice format and was designed to test concept learning. Some items contained static or animated graphics in addition to the text. KR-20 reliability of the posttest was .69.

Research Design and Statistical Analysis

A general linear model (GLM) procedure was used to conduct a regression analysis for the performance measure criterion. The three independent variables Presentation Format (Text-Only and Text-plus-Animated-Graphics), score on VVQ, score on GEFT, and the two-way interactions between the three independent variables were used as the predictors. A correlation analysis was also conducted between the score on VVQ and score on GEFT.

Individuals were identified to be more or less Field Independent using the score on GEFT and the score on VVQ was used to identify individuals to be more or less visual. Thus, both VVQ and GEFT scores were used as continuous variables rather than a dichotomy.

Results

Posttest. No main effects for Presentation Format were detected, $F(1, 185) = 1.96$, $p = 0.16$. All groups performed at a comparable level regardless of the treatment condition. There was a significant main effect for VVQ scores, $F(1, 185) = 5.84$, $p = 0.02$, when VVQ score was considered in conjunction with other predictors in the model. Individuals identified as more visual and those identified as less visual seemed to differ in their performance. However, a low correlation between the VVQ score and the performance measure ($r = -.10$) indicated that the VVQ could be acting as a suppressor variable and may not really be related to the criterion. No other main effects were detected. Interaction of score on VVQ and Presentation Format (Text-Only and Text-plus-Animated Graphics) did not indicate any significance, $F(1, 185) = 1.86$, $p = 0.17$. No other interactions were detected between the performance measure (posttest score) and any of the predictors (Presentation Format, score on VVQ, and score on GEFT).

Correlation between VVQ and GEFT Scores. There was no significant correlation between score on VVQ scores and score on GEFT. Pearson correlation coefficient for VVQ score versus GEFT score was found to be 0.016.

Discussion

This study indicated that there was no significant difference in the performance of individuals based on their level of field independence. This result was surprising. Expectations based on previous studies (Wapner & Demick, 1991) were that the more field independent individuals would score higher on performance measures than the less field independent individuals irrespective of the presentation format. The non-social and analytic nature of the lesson content, the need for proper attention to details, and the requirements of proper encoding of the interrelationship between concepts were believed to favor the more field independent individuals resulting in better performance among this group. However, it is possible that the presentation of the concepts anchored the traditionally difficult concepts of acceleration and velocity to everyday examples and experiences reduced the effect of the non-social aspect of the content. Following the instructional design principles involving instructional strategy -- directing attention, informing learners of the objective, presenting the material -- may have confounded this study and subverted answering the research question. Recent research has also pointed to possible shortcomings of the Group Embedded Figures Test (GEFT) as a true indicator of the field independence-dependence construct (Arthur and Day, 1991).

The outcome of this study indicating no significant performance increase when individuals along the verbal-visual cognitive style continuum were presented with lesson formats matching their visual/verbal preference was also unanticipated. Furthermore, the addition of animated graphics in the lesson did not seem to enhance the learning of concepts. The failure of this study to support results of past research can be attributed to several possible reasons. The most likely reason is that the design of the lesson material in general and the design and placement of the visuals in particular were inadequate. It is also possible that the animation used provided too much visual stimuli (i.e., high level of realism) resulting in learners attending to inappropriate and irrelevant information as has been indicated in research conducted by Dwyer (1987). Though, the content of the lesson in this study appeared consistent with the use of visuals in instruction, the text presentation could have been sufficiently rich in detail and may have effectively prompted the students to spontaneously form mental images of the concepts. Consequently, the use of graphics, static or animated, may have been unnecessary. Finally, another contributing factor for could have been the inability o VQ to correctly identify verbalizers and visualizers.

The failure of this study to provide anticipated results can be attributed to the fact that too many concepts (and interrelationships between them) were presented within a very short span in the lesson. Research in science education has indicated that, in-depth coverage of a single concept is more beneficial than superficial coverage of numerous concepts (Eylon & Linn, 1988).

Follow-up studies should assess level of prior knowledge and ability differences of the participants. Empirical studies show that individuals with minimum science background hold strong conceptions/ misconceptions about some phenomena, conflicting ideas about similar phenomena, and little knowledge of other phenomena. Studies have shown that students maintain their ideas and misconceptions when incorporating new information from instruction (Eylon & Linn, 1988). Strategies such as integration (linking of consistent and unrelated concepts) and differentiation (identifying differences between related concepts) have been encouraged to help individuals develop more robust conceptual frameworks (Hewson & Hewson, 1984). Effects of ability differences have been reported in a study by Doyle (1983). The study indicated that medium and low ability individuals performed better when the instruction was explicit while the high ability individuals became confused. Other factors such as motivation level of the participants and degree of experiences in the use of computers should also be assessed.

The success in the use of visuals, whether static or animated, in enhancing learning has been contradictory. While some researchers have shown that visuals enhance learning (Alesandrini, 1981; Moore, Chan, & Au, 1993), there are others who have found detrimental effects of illustrations provided with text (Saunders & Solman, 1984). Rieber (1990) has indicated that the correct use of animation could help in increased attention, motivation, and learning. However, unless a clear need for animation is seen, its use may result in inhibiting learning because of its distractive effect. For animation to be useful, the content of the domain should offer the basic animation attributes of motion and trajectory (Rieber, 1993). More research is required to develop a stronger framework for the use and design of visuals and their effective placement. Follow-up studies should also investigate the effect of the use of graphics in posttest items on the performance of individuals receiving the Text-Only version of the lesson.

The independence of the two cognitive style dimensions -- Field Independence-Field Dependence (FI-FD) and Verbal-Visual -- suggested by this study was not surprising. Recent studies (Manfredo, 1987) have suggested that the two dimensions are independent of one another and that the position of an individual on one dimension does not affect their position on the other. The two dimensions are also considered to be continuous, with the individuals distributed along each dimension (Riding & Sadler-Smith, 1992).

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