Computers and learning
by Lyndon Cary Marshall

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

Abstract:
Although computer systems have been part of our lives for more than three decades, most individuals are still looking for ways of integrating computers into their life. Many who work with computers frequently question why people react to computers as they do. Why do some like computers, learn them effectively, and do an excellent job of working with them, while others never seem to like computers or work well with them? Learning styles may be an answer. Therefore, the purpose of this study was to investigate the nature of the relationship between learning style and preferences that were held for different types of computer software.

The design for this research was a case study which involved the collection of both quantitative and qualitative data. The primary method for collecting data involved a series of interviews of computer users and observations of these individuals while using different computer software packages. Particular attention was paid to what programs were liked, why particular programs were preferred, and how individuals worked with different computer programs. Additionally, Kolb's Learning-Style Instrument was used to help classify individuals into different categories for the learning of new concepts.

The results of this study helped to confirm the mixed results that researchers have found regarding the effects of learning style on the way in which individuals work. Learning style was not a significant predictor of preferences for different kinds of user software. However, learning style was a significant predictor of how people talked about their work with computer systems. This result is important to both computing teachers and professionals in the computing field. Both have a need to work with the computer novice. This identification of individuals who are more inclined to talk about computers can help in the peer learning process.

Other significant findings from this study highlighted possible cultural issues that can affect the way in which individuals work with computers. Furthermore, gender based differences can affect individual perceptions of the computer in the workplace. These are issues that can affect the adult educator who has to teach technology.

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Date January 15, 1995

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ABSTRACT

Although computer systems have been part of our lives for more than three decades, most individuals are still looking for ways of integrating computers into their life. Many who work with computers frequently question why people react to computers as they do. Why do some like computers, learn them effectively, and do an excellent job of working with them, while others never seem to like computers or work well with them? Learning styles may be an answer. Therefore, the purpose of this study was to investigate the nature of the relationship between learning style and preferences that were held for different types of computer software.

The design for this research was a case study which involved the collection of both quantitative and qualitative data. The primary method for collecting data involved a series of interviews of computer users and observations of these individuals while using different computer software packages. Particular attention was paid to what programs were liked, why particular programs were preferred, and how individuals worked with different computer programs. Additionally, Kolb's Learning-Style Instrument was used to help classify individuals into different categories for the learning of new concepts.

The results of this study helped to confirm the mixed results that researchers have found regarding the effects of learning style on the way in which individuals work. Learning style was not a significant predictor of preferences for different kinds of user software. However, learning style was a significant predictor of how people talked about their work with computer systems. This result is important to both computing teachers and professionals in the computing field. Both have a need to work with the computer novice. This identification of individuals who are more inclined to talk about computers can help in the peer learning process.

Other significant findings from this study highlighted possible cultural issues that can affect the way in which individuals work with computers. Furthermore, gender based differences can affect individual perceptions of the computer in the workplace. These are issues that can affect the adult educator who has to teach technology.

CHAPTER 1

INTRODUCTION

Background

The last few years have witnessed the advent of the information society. This information society is manifested in many different ways. Computers and communications technologies, the driving force behind the development of the information society, are becoming a pervasive part of our daily lives. For example, certain aspects of computer technology have become such an integral part of our lives that we expect and demand the benefits of computer systems. People have come to expect the following services in the everyday workings of their lives: dealing with computer-based automatic teller machines on a 24-hour basis, having groceries checked-out more rapidly and more accurately through the use of computer bar-code readers, obtaining up-to-the-minute weather projections because of sophisticated weather projection computers at the National Weather Service, and tracking monetary information generated by computers at the different financial centers around the world.

The expectation of the benefits from computer systems is all the more pervasive in the work place. This can be readily seen from the fact that at present more than 60% of workers are considered to be individuals whose primary purpose is the creation, manipulation, retrieval, and storage of information (Whitten, Bentley, & Barlow, 1989, p. 33). These individuals are commonly described as knowledge workers. Computer systems are very much an integral part of the work that is expected from knowledge workers. Entry and retrieval of customer information, use of a word processor to type in memos and reports, and the use of computers to track products sold by a company are all common activities for individuals in the work place.

Given the increasing importance of computers in both one's daily and professional lives, it is not surprising to see that increasing levels of private and governmental resources are being devoted to the development of computer software. The level economic commitment to the development of computer systems is reflected by the $70 billion worldwide that was spent on computer hardware and software in 1990 alone (Cringely, 1992, p. 4).

However, with increasing resources comes increasing demands for performance in the computer industry. This is particularly true with software. Purchasers of software are increasingly impatient with software that does not work right and with software that may work right but that is so inconvenient to use that it does not matter if it works right. There is substantial reason for this impatience. In a study of a series of software projects developed for just one government department, $6.8 million was spent for the programming of software. Of the software that was developed from these contracts, only approximately $100,000 of it was used as delivered. The vast bulk of the software, $3.2 million worth, was never delivered; $1.3 million worth of software had to be abandoned or reworked; and $.2 million worth of programs were used after substantial changes (Ince, 1988, p. 4).

Many explanations are offered for this poor performance in the software development industry. In some instances, developers simply do not have a complete understanding of the problem that they are trying to solve with their programs. In other instances, poor software development and testing methods were employed. However, in a large number of instances, software does not do the job because it works in a way that is either inconvenient or unappealing for the people who are supposed to work with it (Ince, 1988, pp. 1-19).

A major component of the effectiveness of software is represented by the nature of the user interface or shell. This controls the way in which users interact with computers. Since the nature of the interactions that people have with computers will be based on the nature of the user interface, the success of computer software is frequently based on user preferences for different types of software interfaces.

The importance of user interface preference in the acceptance of computer systems is highlighted by a number of pieces of evidence. First and most significant is the development of entire journals which are devoted to understanding the nature of user preferences for software and which are devoted to the development of more effective computer software interfaces. The most prominent of these journals is SIGCHI Bulletin (for Special Interest Group for Computers and Human Interaction) from the Association for Computing Machinery.

A second piece of evidence which highlights the importance of user acceptance of software as a factor in the success of computer information systems comes from Merle P. Martin's text, The Analysis and Design of Business Systems (1991). In this book, Martin states:

> Note that designers have no control over the end-user component. Yet if designers are aware of factors describing the end-user, they can design systems to compensate for negative aspects and enhance positive aspects . . . It is no longer appropriate to force the end-user to learn difficult hardware and software systems. (p. 237)

Furthermore, in this same section of text, Martin states that psychological factors such as the way in which information is processed by the individual and the individual's psychology or attitude can be very important factors in the acceptance of software systems (pp. 215-218).

Therefore, given the scope of the investment that many organizations make in computer hardware, software, and training, it is critical to have an understanding about the reactions to computer systems of those individuals who will be using them heavily. Understanding the underlying reasons for an individual's reactions will help to insure that expensive information systems are effectively installed and utilized. This will help to avoid the situation, often cited in systems analysis and design texts, of computer systems not being used for any apparent reason (Ince, 1988, p. 4)

The topic of user preferences is also important because it relates to the teaching of the subject of computers. Since people tend to have a preference for those things with which they work the most effectively, the issue of cognitive style (which seeks to explain how different individuals input and process information differently) is tied to the issue of user software preferences. This is a consequence of the fact that factors such as cognitive style can affect the effectiveness with which individuals can master the subject (Barba, 1990; Foreman, 1990; Sharma, 1987). This should affect teachers of computers in academic settings as well as in industrial settings (where it is particularly important to teach adults how to use new software as part of the systems development process).

However, despite the work that has been done to investigate the relationships among cognitive style, the ability to learn computers, and the preference that one has for different types of user interfaces, little work has been done to try to understand the underlying reasons that different individuals with different cognitive styles prefer one type of user interface from another. Since the interface is the tool by which users interact with computer systems, this is a significant omission.

Much work has been done in the field of computers to try to relate cognitive style to the ways in which individuals work with computers (Chu & Spires, 1991; Clariana & Smith, 1988; Cline, 1991; Ellis, 1989). The general issue of cognitive style in the design of information has received much attention. Currently, it is argued that system design must be adjusted to the cognitive styles of the individuals for which the system is being constructed (Cline, 1991, p.1). This is a major method for insuring the development of truly effective information systems. Additionally, tools such as the Embedded Figures Test and the Meyers-Briggs Type Indicator can be used by systems analysts to assess the cognitive style of computer users. By basing the design of a system on cognitive factors discerned in the user community, the overall functionality of a computer system can be improved. Furthermore, designers can be more certain that the system more effectively meets the cognitive needs of users. Enhancing the functionality of systems can be based on features such as the availability of different computer interaction formats so that users can choose among them and by developing systems with the ability to customize themselves to the nature of the users who are interacting with them. (Cline, 1991)

Other similar arguments have also been offered. These arguments basically state that human cognitive processing must be considered in the development of information systems. This approach to the design and development of computer systems is sometimes referred to as "Cognitive Engineering" (Norman, 1987, chap. 1). In any event, most arguments that are made regarding the effects of cognitive processing on the systems design process suggest that to insure a truly effective software system designers should constrain themselves to design programs that meet the psychological needs of users (Fischer & Lemke, 1988).

Not only has the idea of the application of cognitive style to system design been discussed extensively in books and journals, but the issue of interface design and its relationship to cognitive processing has also been considered (Cline, 1991; Grabinger, 1989; Mandel, 1994). It has been concluded that the appearance of software screens is not that important to the effectiveness of the software. However, the individual making this conclusion also concluded that the sequences of processes that are present in software should be amenable to the internal processes that go on in the human mind (Grabinger, 1989).

Another study concluded that a recognition of cognitive processes is important in the teaching of computer-oriented courses. For example, the shifts in learning styles that have occurred in students over a period of time when they are exposed to Computer Based Training (CBT) systems have been charted. As a result of being exposed to Computer Based Training, learners have demonstrated a distinct shift toward a preference for more concrete experimentation and for more reflective observation as a result of the CBT experience. (Clariana & Smith, 1988)

Furthermore, direct research has been done that reflects the effects of cognitive style on the ability of individuals to learn the subject. The ability to succeed in computer programming classes is often reflected in the level of impulsivity or reflectivity that is present in the individual who is learning to program. (Van Merrienboer, 1990)

Therefore, the subject of cognitive processing and its effects on the nature of human-machine interaction has received substantial academic attention. From this attention, it can be concluded that it is important to understand the nature of mental processes that go into interacting with computers. Indeed, one researcher approached the subject from the standpoint of the individual who is interested in effectively structuring the manner in which social entities, such as companies, interact with the functionality of the computer system (Zuboff, 1988). This process of constructing effective modes of computer and social organization interaction, systems analysis and design, is increasingly devoted to an understanding of the modes of cognitive processing of the individuals who will be working with a computer information system. This blossoming interconnection is reflected in a number of ways. However, it is most effectively demonstrated by the fact that texts on systems analysis and design include chapters which are devoted to recognizing the potential effects on the design process of the varying cognitive processing styles among the people with which the analyst will be working. Examples of this trend toward the recognition of the importance of cognitive processing include Martin's (1991) Analysis and Design of Business Information Systems (chap. 7, pp. 215-238) and Principles of Information Systems Management (Ahituv & Neumann, 1990, chap. 2, pp. 35-72).

Despite the research that has been done in this area, some basic questions have not been asked. The answers to these might be useful in understanding the basic underlying structure of the process of human-computer interaction. These questions relate to the user interfaces for software and the effectiveness of users in working with them. One such question relates to determining why an individual with a certain cognitive style prefers to work with a certain type of computer user interface.

While there are numerous reasons for needing to know why users who process information in varying ways prefer a certain user interface, there is one underlying and very compelling justification: economics. Systems will not be successful if they are not supported by the user community. Since the user interface is the primary element by which users interact with the computer system, it is critical to understand the underlying processes for liking or for disliking a particular interface.

This understanding of the underlying processes for liking or disliking user interfaces is demonstrably different from the kinds of research into the nature of user interface preferences that has been done before. Existing research has basically established that there is a relationship between interface preference and cognitive style and that designers need to provide for the availability of multiple interfaces to accommodate different human information processing styles. Therefore, instead of continuing work on establishing a relationship between human information processing styles and interface preference, the focus of further inquiry should begin to address the following subject: why do learners of a certain style prefer a certain type of user interface?

In pursuing the question of why computer users prefer a particular type of user interface, broad categories of user interfaces will have to be identified. User interfaces fall into two primary categories: command line interfaces and graphical user interfaces (Deitel, 1990; Mandel, 1994, pp. 1-28).

Graphical User Interfaces are characterized by the use of an input-output device, called a mouse, to point to different programs that the user wishes to run. Examples of operating systems that use GUI's include Windows, OS-2 Presentation Manager, MacIntosh System 7, and X-Windows.

Command Line Interfaces are characterized by the appearance of a system prompt (for example, A> or C>) at which the user is expected to type in a syntactically correct command line to get programs to execute. Examples of Command Line Interfaces include the various versions of MS-DOS, PC-DOS, and Unix.

Problem

Two major themes are revealed in examining the relationship between cognitive style and preferences for software. First, user preferences will affect the acceptance and the success of software systems. Secondly, cognitive style will affect the success that individuals have in working with and in learning software systems. However, the full nature of the relationship between preference for a particular type of software and cognitive processing style remains clouded. Why people prefer what they prefer remains a mystery.

Purpose

Therefore, the purpose of this study was to discover underlying reasons that individuals with different cognitive styles prefer each of the major different types of user interfaces. In this regard, this study can serve to provide additional depth of understanding of both cognitive processing and user interface preferences.

Significance of Study

Underlying information about why an individual with a certain cognitive style will prefer a certain type of user interface can prove to be truly useful to professionals in a number of areas. First, in knowing the reasons that individuals with a certain type of cognitive style prefer a user interface, educators can be better able to aid students to overcome difficulties which are engendered by the preference for a particular type of user interface associated with a particular cognitive style. Second, educators in understanding the underlying reasons for preferring a particular type of user interface can be better able to select teaching tools that match the cognitive styles of the students with which they are working. Third, by being aware of the reasons an individual with a different cognitive style prefers a certain type of user interface, software and systems designers can be better able to develop operating environments that meet the needs of users with different cognitive styles.

Also, advantages would exist for educators in understanding why people with different cognitive styles prefer working with a certain user interface. In understanding this, a wide range of tools can be placed in the hands of the instructor. Among these tools is a fundamental understanding that there is a crying need to not only use the right software tools for the right audience but also to attack and emphasize the ideas and subjects that are of particular concern to the individual with a certain way of processing information.

Understanding the nature of interface preference and cognitive style for processing information will offer a number of other distinct benefits for computer specialists. First, this would give computer professionals who design the structure of information processing in organizations, systems analysts, some tangible information about why individuals like or do not like a particular software user interface. This understanding could offer the analyst a number of advantages. First, it would permit the analyst to select software tools that are appropriate to the environment and to the preferences of the users with which the analyst will be working. Second, it would permit the analyst to direct the user training program to focus on the issues that most concern the people who will work with the system. Third, having some idea of the reasons behind user preferences for software interfaces could give the computer systems designer a more effective concept of when it is appropriate to use a particular interface in an individual organizational setting. Fourth, an understanding of the reasons for users preferring interfaces would open systems analysis and design to a fuller range of tools related to the evaluation of user cognitive style for understanding the organizational dynamic for interacting with computer systems.

Researcher Background

This study has its roots in the background of the researcher who carried out this study. As such, it reflects ideas that have been in development for the more than 20 years that this individual has been a computer professional.

In watching people work with computer systems, it has been very apparent to this researcher that some very intelligent people, who should have little difficulty in working with computer systems, suffer from high levels of anxiety when interacting with computers. One often hears the complaint that individuals are afraid to touch specific buttons because of the fear that the machine will explode.

There has to be a reason for this kind of fear. It must lie somewhere in the way in which computers and software are constructed and used. It must lie somewhere in the way in which computer people interact with new users of computers.

In any event, given the significant time that this researcher has had to spend over the years calming and reassuring the neophyte computer user, this individual has developed an article of faith that understanding the root causes of the fear that many carry into their interactions with computers will help combat the growth and development of the distaste, distrust, and loathing that many bring to their initial work with computers.

Research Questions

Several research questions were addressed in this study. These questions included:

1. How do users with different cognitive styles react to command line interfaces?

2. How do users with different cognitive styles react to graphical user interfaces?

3. What do users with different cognitive styles identify as the best and worst features of the different types of user interfaces?

4. Why do users like or dislike certain features of a particular interface?

5. How do users with different cognitive styles interact with the different interfaces?

Definition of Terms

Cognitive Style: The way in which an individual tends to process the new ideas and information that are encountered in the environment. There are different approaches to Cognitive Style. Some tend to take a look at sensory modalities while others emphasize internal information processing approaches (Nunney, 1978, p. 50).

Command Line Interface (CLI): This type of software interface employs sequences of commands that are typed when the software indicates that it is ready to receive commands. The sequence of commands must adhere to a strictly developed command structure or syntax. Examples include MS-DOS, Unix, and CP/M (Mandel, 1994, chap. 6).

Directories: A segment of a storage device such as a disk or a hard disk that is oriented toward storing similar information. The need for directories is based on the fact that disks as used in modern computer systems tend to be very large, with typical storage capabilities exceeding 100 megabytes. Navigating through directories is a major functional difficulty in Command Line User Interface environments.

Function Keys: These are keys that frequently appear on computer keyboards with legends such as "F1" or "F8." They are usually used to activate specific program or command operations.

Graphical User Interface (GUI): A type of software interface that is characterized by the use of the mouse and by the use of graphical images or icons to represent the programs that can be run. Programs are activated by using the mouse to move a pointer over the icon that represents the program that is to be run. Examples include Windows, OS/2 Presentation Manager, and MacIntosh System 7 (Mandel, 1994, chap. 7).

Groups: A concept from Graphical User Interfaces. It is a collection of related icons that exist under a single controlling icon. The icons in a group represent programs that have a similar purpose or a related function. This is related to the older operating system concept of directories.

Icon: A program symbol in operating environments such as Windows. Users employ a pointing device called a mouse to activate a program by pointing at the icon and by using the mouse to double-click on the icon of the program that they want to run.

Learning Strategy: The basic set of tactics that an individual uses in approaching a learning task. This tends to be relatively more changeable than learning style. Learning strategy will vary from learning task to learning task.

Learning Style: Similar to Cognitive Style, it relates to the way in which individuals tend to learn new information that they encounter in the environment. It also refers to individual preferences for how information is presented to them. For example, some individuals learn best by experimenting while others learn best by observing (Nunney, 1978, p. 50).

Menu: A list of options that is displayed by programs for users from which they make choices. Menus can appear as part of the operating system, as part of a shell in which users choose what programs that they want to run, or as part of a program such as word processor in which users choose what part of a program that they want to run (Mandel, 1994, chap. 6).

Mouse: A pointing device used in Graphical User Interface environments for selecting programs that an individual wants to run.

Operating System: The basic controlling program that enables computer systems to function. Requests to computers to get programs such as word processors to function are usually handled by the operating system. The user interface is one part of the operating system. Examples of different operating systems include MS-DOS, CP/M, Unix, Windows, X-Windows, and OS/2 (Deitel, 1990, chap. 1).

Prompt: A signal from a program that it is ready to receive commands. In MS-DOS, the prompt is represented by symbols such as C> or A>. The > represents command readiness. The letters represent the currently active disk drive storage device. This is the location from which data or programs will be found.

Shell: This is the face that a piece of software shows to the external world. As such, it is very similar to an interface. However, it is frequently used to refer to programs that are meant to aid in the functioning of Command Line Interface programs. Menu systems for MS-DOS are typical examples.

User: This is an individual who interacts with a computer system by working with computer programs of any sort.

Limitations

Participants were chosen for this study from the local computer-using populace. It is possible that individuals in other regions may react differently to computer user interfaces.

Delimitations

Participants were chosen for this study from a number of different professions. These professions included college professors, college administrators, students, secretaries, engineers, Air Force officers, video technicians, and nurses.

Assumptions

It is believed that the people selected for this study represented a fairly broad spectrum of computer users in ability and knowledge. Further, because of the wide range of learning styles that were represented, it is believed that a very typical range of reasons and approaches to computer use was present in study participants.

CHAPTER 2

REVIEW OF LITERATURE

Learning Styles

While the concept of looking at learning style or the way in which individuals process new ideas and information is relatively new, the idea of classifying individuals according to various different psychological typologies has been a recurring theme among the students of the human mind. One of the oldest and most pre-eminent of these typologies was developed by the great psychologist, C. G. Jung. In his works, he described various personality types that would, according to his vision, affect assorted aspects of personal and social reaction, including approaches to learning and solving problems. Among the different personality types described by Jung (1921) are the Apollonian, the Dionysian, the Epimethian, and the Promethian.

While these personality types focus primarily on broad personality issues, aspects of learning style do intrude in this discussion of different types of people. For example, substantial aspects of Jung's work are devoted to personal approaches to problem solving and to whether or not an individual looks inward (introversion) as a way of solving problems or outward (extroversion) in problem solving. Furthermore, Jung devotes much discussion to examining whether an individual relies more on the rational mind or on emotions when dealing with difficulties.

The psychological typology proposed by Jung lay in dormancy for a long period of time. However, in recent years, others have taken up this approach to looking at the human mind and its different facets. One of the most prominent attempts to examine psychological types is the Meyers-Briggs Type Indicator. Essentially, this instrument employs the Jungian categories as the basis for classifying the personality types of individuals (Keirsey & Bates, 1978, pp. 3-4).

However, for a number of decades, the idea of examining human temperament and aptitudes from the perspective that there are basic, underlying, built-in reasons that individuals differ in how they do tasks than do others fell into disrepute. Belief in a new form of scientific objectivism called Behaviorism started to grow. Around the beginning of the Twentieth Century, a group of psychologists began to assert that the nature of the human mind could be directly understood through the objective lens of the external study of an individual's response to stimulation. In this regard, some of the more radical members of the Behaviorist school held that internal individual differences, preferences, and abilities were totally irrelevant. The only thing that should be considered is the nature of the experiment and the person's reaction (Hunt, 1993, pp. 242-275).

Many researchers found the viewpoint of the Behaviorist model of the human mind to be too limiting. Consequently, a new approach to understanding the mind called Cognitivism started to develop. In contrast to the approach advocated by the Behaviorists, Cognitivists believed that internal differences between humans in terms of preferences, abilities, and styles of learning were the most important concepts that could be studied about the human mind. In fact, the interest in the internal structures of the human mind has been carried to such a point that there is a tendency among many students of psychology to use a computer analogy in discussing the mind and to describe the mind in terms of components such as input-output (perception), storage (memory), programming (instinct and learning), and processing (Hunt, 1993, pp. 511-558).

Despite a tendency not to agree on anything, students of psychology have been coming to a conclusion that the human mind is more complicated than previously believed. Consequently, strongly held positions have had to be modified or enlarged.

> In fact, each one of the principles confidently enunciated by Skinner in The Science of Learning and the Art of Teaching now turns out to be untrue--at least in as general a sense as he believed at that time. (McKeachie, 1974, p. 186)

In acknowledging the fact that the human mind is much more complex than had been imagined by many and particularly the Behaviorists, numerous different approaches to attempting to understand how and why people learn have emerged. Some of these different schools of psychology and learning include social psychology, perception psychology, motivational psychology, cognitive psychology, and psychotherapy. Each of these schools has a different approach and set of issues that they consider to be important in understanding the human mind. However, certain common themes emerge in considering the essential directions of these different approaches to psychology. Some do not study learning theory at all or only consider it as a distinctly peripheral issue. Others have shifted their emphasis from studying the individual patterns in learning to studying "between-group differences such as racial differences, sexual differences, and social class differences" (Ivey, 1992, p. 38). Still others have become fascinated with micro-level functioning of the human mind and have considered only the neuro-physiological brain, the collective functioning of a series of conjoined organs with a common blood supply.

> Three words . . . go a long way toward telling the whole story--"mind," "matter," and "intellect." The contemporary view of mind denies the intellect as a distinct faculty--a special power of the human mind that makes it radically different in kind, not just in degree, from the minds of all other animals on earth. (Adler, 1990, p. vii)

The consequence of these obsessions with issues such as the macro (how groups behave) and the micro (how neurons function) is that the study of a very fundamental issue, the investigation of individuals and of individual learning styles, has been left incomplete.

Hierarchy of Learning Styles

In his 1992 dissertation, Ivey discusses an effort to organize the different theories and instruments that have been developed with respect to learning style. The primary issue that was raised with the different instruments was described as "psychometric acceptability." In arriving at this issue of acceptability, the primary criterion was the meaningful collection and reporting of data concerning the reliability and validity of the various instruments that were assessed for the study (p. 38). Applying this standard, the vast majority of the tests were eliminated from further consideration and nine of the tests were placed in a three-level, concentric hierarchy.

The center of the hierarchy was occupied by those theories that are organized around describing the cognitive personality. Tests in this group include Witkin's Embedded

Figures Test and the Meyers-Briggs Type Indicator. The second level of the hierarchy was oriented toward models of the ways in which individuals process information. Kolb's Learning-Style Model falls into this category. The third level concerns instructional preferences or the environment in which the individual works most effectively (p. 39).

In occupying the center of the model and trying to describe cognitive personality, the primary objective of Witkin's Embedded Figures test is to measure the amount of field dependence or field independence that an individual has. The purpose of this measure is to determine an individual's tendency to apply analytical models in the solution of a problem as compared to the person's proclivity for needing global information to be able to understand things.

As with most of the models that made it through the screening tool of having basic reliability and validity information available, Embedded Figures does have some difficulties. Primary among them is the fact that it only assesses part of what it claims to. In fact, it really only determines the amount of field independence that a person possesses. The amount of field dependence that a person is subject to is implied by the lack of field independence (Bonham, 1988, p. 12). Whether field dependence and field independence are complementary in this fashion remains to be seen.

The outermost part of the hierarchy of tools and theories is oriented to the environment in which individuals would like to learn. One such instrument is the Dunn LSI. It focuses on learning environment, emotionality, sociological needs, and physical requirements (Dunn & Dunn, 1978). Another instrument in the second category is the Grasha-Reichmann Student Learning Style Scales which measures the degree to which students are collaborative, competitive, participant, avoidant, dependent, and independent (1974).

A number of instruments fall into the middle category of learning style theories which purport to deal with the ways in which individuals assimilate and process information. One such example in this category is the work of Entwistle (1981). This theory describes two forms of learning. These forms are "deep" and "surface" learning (p. 105).

However, the most famous of the instruments and theories that fall into the middle category are those of Kolb. There are two basic aspects of Kolb's theories. These include the Learning-Style Inventory and the Experiential Learning Model.

Kolb and Learning Style

In describing the Experiential Learning Model, Kolb characterizes his theory as being very similar to the personality types theory that was originated by Jung. In this regard, he describes his structure as being essentially dialectical in nature because it is composed of tendencies that are essentially in opposition to one another but that come together in the human being because of the controlling nature of the higher intellectual processes (Kolb, 1981, p. 235).

The four aspects of the Experiential Learning Model include Concrete Experience, Observations and Reflections, Formulation of Abstract Concepts and Generalizations, and Testing Implications in New Situations. According to the model, the individual will in any learning situation use varying combinations of the knowledge-building approaches implicit in the paradigm. What combinations are used will depend on varying factors such as the learning situation and the personality of the learner.

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     -------------------->Concrete--------------->
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     |                                           |
     |                                           |
Testing Implications                    Observations and
of concepts in New                        Reflections
Situations                                       |
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     |                                           |
     |                                           |
     |                                           |
     <------------Formation of Abstract <--------<
               Concepts and Generalizations
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Figure 1. Kolb's Experiential Learning Model.

Kolb's learning styles flow directly from his description of the Experiential Learning Model. Basically, following an information processing approach to understanding how individuals learn, he describes four primary cognitive tasks that an individual must go through in a learning situation: Concrete Experience, Abstract Conceptualization, Active Experimentation, and Reflective Observation. In the Learning Style Model, these tasks are placed on orthogonally situated axes. The vertical portion of the axis represents the two diametrically opposed methods of learning Concrete Experience and Abstract Conceptualization. These two qualities are primarily oriented toward understanding how an individual perceives information.

In contrast, the horizontal dimension of Kolb's Learning Style emphasizes the processing of information. The two elements that describe how individuals process information are Reflective Observation and Active Experimentation.

In Kolb's Learning-Style Inventory, one primary fact that should be emphasized is the fact that both of the scales in the inventory represent scales or spectra. Generally, individuals will not have all of one quality and none of the other on a particular axis. Rather, varying combinations of each of the qualities on an axis will be present in each individual.

There is still a further aspect to the Learning-Style Inventory. The two axes of perception and information processing in the model combine to create four quadrants. These are the learning styles that Kolb seeks to identify. The four distinct learning styles include Convergers, Divergers, Accommodators, and Assimilators.

Kolb describes the different learning styles in some depth. For example, Convergers combine a propensity for Active Experimentation with a fondness for Abstract Conceptualization. These individuals seem to function most effectively in the situation typified by the traditional intelligence test. This is where there is a single correct answer to the question being asked (Kolb, Ruskin, & McIntyre, 1974, p. 30). Kolb suggested that these individuals would function most effectively in areas such as science and engineering.

In contrast, Divergers combine a fondness for Concrete Experience with an orientation toward Reflective Observation. Individuals with this learning style take an entirely different approach to intellectual issues. They are people oriented, like to work in groups, specialize in the generation of ideas during group discussions, and tend to excel in the arts (p. 31).

Accommodators prefer to obtain information through Concrete Experience and to process information through Active Experimentation. According to Kolb, these individuals are doers and are characterized by a high degree of flexibility. Individuals with this learning style make good sales people (p. 31.).

Assimilators like Reflective Observation and Abstract Conceptualization. These are idea people. They are not necessarily interested in the practicality of ideas (p. 31).

Learning Style and Intellectual Ability

In terms of linking an individual's success with different subjects and learning style preferences, there have been mixed results. On the positive side, it appears that the ability to successfully work with subjects that are based in high levels of abstract conceptualization is associated with a learning style which includes a preference for abstraction. This was demonstrated in a study in which learning style was compared to a student's ability to function with abstraction as represented by effectiveness in operating with experimental science processes. In this regard, those students who preferred work at the concrete level did less well in the test of experimental processes than did students who liked abstraction (Nakayama, 1988).

In contrast, a number of studies have not found any relationship between intellectual ability and results on learning style. The studies that have shown no relationship have occurred in a number of different academic settings and with different academic disciplines.

One example of a study that found no association between learning style and subject success came from an examination of a collection of freshman college students. In this investigation (Davis, Murrell, & Davis, 1988), the learning style as determined by the Kolb Learning-Style Inventory was compared to the grade that a student obtained in a course. Further, the student's learning style was compared to the learning style of the instructor. In this regard, it was found that there was no relationship between grade and learning style and that there was no significant difference in the grades of students whose learning style matched the learning style of their instructors.

Learning Style and Disciplinary Area

While there is no strong reason to associate learning style and the ability to work in a particular subject, there does seem to be a tendency for individuals with similar academic backgrounds to have similar learning styles (Kolb, 1981, pp. 240-244). For example, individuals who have been trained as engineers or computer scientists tend to be what Kolb would describe as Convergers or individuals with a preference for Active Experimentation and Abstract Conceptualization. Similarly, individuals who have been trained in business, accounting, or finance tend to be Accommodators because they have a preference for Active Experimentation and Concrete Experience.

Researchers have reported that work in particular academic areas can cause individual learning styles to shift. In one study (Clariana & Smith, 1988), students were tested for learning style before an extensive exposure to a mathematics course. Afterwards, they were tested again. A shift toward a preference for Reflective Observation occurred.

Results such as this can lead to a number of conclusions. First, if learning style can shift due to some external influence, then it is probably true that learning style is not a permanently wired-in aspect of how the human mind processes information. Secondly, understanding how individuals learn is more complex than is even imagined by the advocates of learning style. In fact, in order to improve teaching and learning in all disciplines, "more is needed than a knowledge of a student's learning style" (Conti & Welborn, 1986, p. 22).

Criticisms of Learning Style

There are a number of criticisms of learning style. These criticisms come from a number of different individuals and have a number of different bases. Sometimes the criticisms are fair, but in some instances they are not.

One area in which learning style receives substantial criticism lies in the fact that there are often validity and reliability issues that are legitimately raised with respect to the instruments that are supposed to measure them. For example, of 21 different learning style instruments that were examined for psychometric acceptability only 9 were accepted (Ivey, 1992, p. 38).

Another area in which learning style instruments have been criticized comes from them potentially suffering from cultural or economic biases. In this regard, a number of the instruments tend to be biased in favor of those individuals who are from the upper portion of the social, educational, and economic spectrum. In particular, Kolb's instrument has been directly condemned for using normative groups that are not so typical of the population as a whole (Sewall, 1986, p. 25).

However, a number of the critiques of learning style and learning style inventories have not been completely well-founded. For example, in criticizing Kolb for having an instrument that is culturally biased, some authors miss the fact that this is a criticism that can be levied against many forms of cognitive ability testing (Helms, 1992, pp. 1083) and that this has been a very egregious problem for intelligence testing for some time (Gould, 1981).

In another example of criticisms that may not have been appropriate, some commentators attacked learning style and Kolb for lapses that were present in their own methodologies. One study purported to investigate the validity of Kolb's instrument by using an instrument that, in turn, had not been validated and that may not have been reliable (Fox, 1984, pp. 83-84).

Another study (Ferrell, 1983) was oriented toward furthering a certain viewpoint of cognition. This approach to cognition was enunciated by Keefe (1982) and asserts that learning style is based on three components, which consists of cognitive, affective, and physiological behaviors. In Ferrell's paper, four learning style instruments were examined (Grasha and Reichmann's SLSS, Kolb's LSI, Johnson's DMI, and Dunn's LSI). Each of the different learning style instruments was strongly criticized by Ferrell (1983) for not following Keefe's framework.

Other Aspects of Learning Style

There have been many different approaches to trying to understand the different ways in which human beings learn. One of the most prominent of these is called Multiple Intelligence Theory. In this framework, it is believed that there are different aspects to intelligence and that these different aspects are possessed in varying degrees by different individuals. The different intelligences include linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, and interpersonal (Gardner, 1993).

According to the advocates of Multiple Intelligence Theory, this concept is not really the same thing as learning style because it does not attempt to explain or discuss different preferences for how information in obtained or processed. Instead, what it attempts to explain is the differing abilities that individuals have in different subject areas (Gardner, 1993, pp. ix-xxv).

Divided Learning Style. Some students of learning style take an approach similar to Gardner in advocating that there are different aspects to intelligence. However, in distinct contrast, researchers such as Keefe identify only three basic aspects to intelligence (cognitive, affective, and physiological), and they have studied ways of assessing particular individual styles within the three primary aspects of intelligence (1982).

Following this approach, Keefe has identified a number of instruments that fit into the different aspects of intelligence. For example, a number of instruments are designed to identify the cognitive aspect of intelligence. Included in this area is the Edmond's Learning Style Identification Exercise (ELSIE) which is "concerned with the ways students internalize individual words" (Keefe, 1982, p. 45). In accomplishing this particular objective, ELSIE is a method for detecting the perceptual modes that an individual has.

Also falling into the category of assessing the cognitive aspect of intelligence are the Group Embedded Figures Test (GEFT) developed by Witkin (1978) and Gregorc's Style Delineator (Gregorc, 1979, pp. 234-236). In Gregorc's model, information processing is the primary idea that is examined. As such, this knowledge handling is described as having two dimensions, abstract vs. concrete and random vs. sequential. Therefore, individuals will have a learning style that falls into a combination of the two dimensions. For example, an individual might be classified as Abstract Random (AR), Abstract Sequential (AS), Concrete Random (CR), or Concrete Sequential (CS).

In the Group Embedded Figures Test, individuals are asked to find shapes inside increasingly complex geometric figures. This ability to find the shapes determines how Field Dependent or Field Independent that an individual is (Oltman, Raskin, & Witkin, 1971). Field Dependency is a measure of how much an individual needs associated and background information to understand how something works (Witkin, 1978).

Several different instruments have been identified to assess the affective aspect of intelligence. One such instrument is the Paragraph Completion Method (Hunt, Butler, Noy, & Rosser, 1978). With this instrument, respondents are given statements about which they are supposed to write additional sentences which reflect their feelings about the subject. The manner of completion of the paragraphs tells how much structure individuals need in their learning process (Keefe, 1982, p. 49).

Another instrument that seeks to examine the affective aspects of intelligence is the I/E Scale (Rotter, 1966). This questionnaire presents a series of alternatives that describe events in a person's life. An individual taking this test is expected to select from one of the alternatives in each scenario. Each alternative will either represent an internal or external locus of control of the individual's actions (Keefe, 1982, p. 49).

Physiological styles are "biologically based modes of response that are founded on sex-related differences, personal nutrition and health, and reaction to the physical environment" (Keefe, 1982, p. 49). Several instruments address the different possible learning styles which are implicit in this aspect of intelligence. Among them are Dunn's Time Questionnaire which permits an individual to chart the preferred working times throughout the day (Dunn, & Dunn, 1978).

As can be seen, there are many different aspects to intelligence, and "no current learning style instrument provides a truly comprehensive assessment of the cognitive, affective, and physiological domains of learning style (Keefe, 1982, p. 53). Consequently, much room remains for study and understanding in this field.

Learning Strategy

There is a vast richness to the way in which individuals deal with learning and problem solving. One aspect of problem solving is learning strategy. While learning style is considered to be a relatively persistent trait in that it is considered to be a fairly permanent part of the way in which a person deals with the world, learning strategy is the differing skills that an individual brings in the solution of a particular problem or in learning a particular subject (Conti & Welborn, 1986, p. 20). In dealing with the subject of how well different individuals adapt to different computing environments and to varying computer programs, this subject will inevitably come up.

Metacognition, metamotivation, memory, resource management, and critical thinking are the five key components of learning strategy (Conti & Fellenz, 1992). Metacognition is the self-examination of internal processes that one uses in learning. Metamotivation is the internal processes that an individual uses to describe the importance of learning a particular subject. Resource management is the propensity that one has for effectively using various resources to help learn a particular subject. These resources could include friends, experts, or books, for example. Critical thinking is the ability that an individual has for skeptically examining the context and background of the concepts that are presented to them. Memory is the ability that one has to retrieve information that has been assimilated.

Learning Style and Cognitive Style

There is a tendency to link the concepts of learning style and cognitive style. In many ways this is legitimate because the two concepts are intimately related.

However, despite the closeness of the connection, there are some important differences between the two concepts. In many ways, learning style is a much broader concept than is cognitive style. Learning style addresses a broad range of factors that can affect the effectiveness of the learning process. According to Keefe (1982, p. 44), these factors include the cognitive, affective, and physiological traits that can affect the learning process. In contrast, cognitive style is directly focused on only those things that affect the processing of information. This would include both the input of information (sensory modalities) and the way in which information is processed by the brain (pp. 44-45).

However, the similarities between the concepts outweigh the differences. This could be due to the dominance that cognitive style has in the various learning style models (Keefe, 1982, chap. 1).

Computers and Cognition

A Brief History of Computing

Understanding the problems and opportunities that individuals have in interacting with computers is at least partially based on a comprehension of the developmental history of computers, and microcomputers in particular.

Until the late 1970's, the dominant form of computer was something called the mainframe. To say the least, these devices were not user-friendly. To get any information from them, they required special operating environments and armies of specially trained programmers (Long, 1991, chap. 2).

The difficult nature of getting information into and out of these early mainframe computers was reflected in the fact that operating these computers was a technical specialist job of its own that required a separate knowledge of a different programming language such as something called JCL or Job Control Language. The purpose of devices such as JCL was very similar to that of modern operating systems in controlling devices and in assisting regular programs in running. (Long, 1991, p. 502)

However, the late 1970's saw the advent of the microcomputer. The basis for their invention, the microprocessor that had been invented earlier in the decade by an engineer named Ted Hoff, was incorporated by a number of engineers as part of kit-based personal microcomputer systems. Later, faced with the increasing popularity of certain types of software systems, notably spreadsheets, manufacturers such as Apple started shipping pre-assembled microcomputer systems to their non-engineer customers. (Ranade & Nash, 1994, pp. 3-7)

During this initial period of computer use, microcomputers definitely reflected their origins in mainframe computers. This was demonstrated by the nature of the operating systems that were used in computers to help run programs. In this period, the microcomputer industry was dominated by an operating system called CP/M for Control Program/Microprocessor. This operating system was very much like its mainframe-based predecessors such as JCL in that it was cryptic, difficult to understand, and required a high level of expertise to be able to use effectively. Casual users were not welcomed in this operating environment where it was extremely easy to lose every file on your disk. (Kildall, 1994, pp. 205-211)

Glimmerings of change started to be felt in the computer industry in the early 1980's with the introduction of the IBM PC. Accompanying the introduction of IBM PC and spurring its popularity was a program called Lotus 1-2-3. Here was a program that almost everyone who needed to track financial information absolutely had to own. Thousands of IBM PCs were sold on the simple basis that individuals wanted to track their personal and corporate finances by using Lotus 1-2-3. (Williams, 1994a, pp. 417-422)

However, one major problem existed in this environment. The operating system that was used to help other programs, such as Lotus 1-2-3, operate properly was something called MS-DOS or Microsoft's Disk Operating System. In order to keep commands that were compatible to those that were used in CP/M, which dominated the computer market at the time, MS-DOS was designed to look, act, and feel just like its earlier, cryptic cousin. The consequence of this was that computer users still had to be initiated into an arcane language in order to be able to run one simple program. This is the origin of the command line interface. (Paterson, 1994, pp. 212-219)

Not long after the introduction of the IBM PC, other developers of computer systems began to wonder why it was necessary to continue to perpetuate the unfathomable methods of communicating with computers that had been used up to that point. Consequently, the engineers at Apple Computers introduced computers that were based on the use of program symbols called icons, on a pointing tool called a mouse, and on an activation process that involved clicking a button when you wanted to run a program. This process of running programs had been developed a few years earlier by engineers at Xerox's Palo Alto Research Center (PARC) and had been intended to make it substantially easier for untechnically-oriented people to use computers with ease and facility. This is the origin of the graphical user interface. (Williams, 1994b, pp. 397-412)

Since the development of the two major operating environments, command line interfaces and graphical user interfaces, there has been an ongoing argument in computer circles as to which method is better. Both sides have many adherents and as many different reasons for liking what they like. Some users state that ease of use must be the prime consideration and that graphical user interfaces are superior. Others state that the ability to control all aspects of computer operations is more important and that command line interfaces are better. In any event, it is difficult to reconcile the two groups. One might suspect that the issues are more profound and complex than might be inferred from the surface of the argument.

The Psychology of Computer Programming

One of the seminal works in attempting to understand the psychological aspects of computing is The Psychology of Computer Programming (Weinberg, 1971). While much of the text is devoted to the technical aspects of good computer programming languages and to the requirements for writing good computer programs, substantial parts of it are oriented toward the social and psychological aspects of computing.

Weinberg makes several major points about the sociology and psychology of programming. First, organizations which are going to depend on computer technology to run a business should insure that software is developed according to the Egoless Programming paradigm. This means that computer programs are developed according to standardized methods that are understandable and that these programs are completely documented. This will help to keep the programming "artist" from developing programs that work elegantly but that are composed of programming statements that nobody else can understand or alter. Organizations which permit their programming staffs to write programs that do not adhere to Egoless Programming will inevitably suffer harmful consequences because individuals die, retire, take other jobs, or get an inflated view of their own self-importance. The inescapable consequence of over-dependence on a single individual is software ending up as useless junk because nobody can fix the problems with the programs (Weinberg, 1971, pp. 47-65). This inevitability of having to alter computer programs was underlined by Brooks (1982) when he wrote, "A program doesn't stop changing when it is delivered for customer use. . . . The total cost of maintaining a widely used program is typically 40 percent or more of the cost of developing it" (pp. 120-121).

Another major theme of Weinberg is that computer programming is, or should be, a social activity. In this regard, when working on large projects, it is destined that differing individuals will have diverging levels of expertise when working with varying technical projects. Therefore, to work the most effectively as a computer programmer, an individual must have the ability to work competently in groups (pp. 67-93).

Furthermore, Weinberg attempted to identify the psychological characteristics of the effective computer programmer. Among these characteristics include flexibility, adaptability, tenacity, level of intelligence, the ability to tolerate stress, some humility, and a sense of humor. However, it should be noted that Weinberg is skeptical of the use of psychological tests to measure either the personality or aptitudes of programmers because of the "inadequacy of our knowledge of which personality factors play what role in which part of the programming process" (p. 158).

However, one of the most important parts of Weinberg's work is his attempt to identify the characteristics of good computer programs. Among the characteristics identified were efficiency, reliability, and ease of use (pp. 15-26).

Nonetheless, his attempts to identify the characteristics of computer languages that would more effectively fit the cognitive processing patterns of computer programmers may actually be more informative for the typical user of modern complex computer programs. The list of such characteristics includes consistency of operation, extensibility of operation (the ability to get the language to do a variety of things), the compactness of the language, and uniformity of operation (pp. 206-243).

Other writers have identified similar issues in the design of effective software user interfaces. When asked to consult on what should be important in the design of software interfaces, Cognitive psychologists have listed three primary principles of design, including placing users in control, reducing user memory load, and making the interface consistent (Mandel, 1994, pp. 77-94).

Computer Semiotics

Since semiotics is the study of how the meaning conveyed in symbols affects the communications process, one group of researchers in the design of computer software asserts that understanding the nature of effective user interface design should be based on the use and meaning of signs that are inherent in language. Furthermore, these symbols should be based on the social and cultural aspects of the role of language in communicating meaning. As stated by Andersen (1990), a semiotic approach to the designing computer interfaces must involve the following elements:

> it should recognize that most work is collaborative, involving more than one person, and that cooperation involves conversation that could be supported by computer systems;
>
> it must recognize the aspects of work that do not consist of information processing;
>
> it should involve users actively in the design process;
>
> it should focus on the current practice of the users since needs for design have their roots here;
>
> it must view language as a social phenomenon used for communicating and coordinating work, not only as a phenomenon of the individual mind;
>
> it must give understanding of creative use of signs, an understanding which must be formalizable, since creative use of computer-based signs involves formalization;
>
> it must respect actual language usage as the basis of analysis. (p. 5)

In making statements such as these, writers are making the assertion that the meaning that individuals give to words, ideas, and symbols are a critical element in the information that is conveyed in communication and that it is this meaning that forms the basis of individual preferences for communicating with different kinds of symbols in computer systems.

Learning Style and Computers

One idea that has received the attention of a number of researchers is whether learning style has an affect on one's ability to work with computers. Mixed results have come from these various attempts to link learning style and success with computers.

One measure of learning style is that of reflection-impulsivity (Kagan, 1965; Kagan, Rosman, Day, Albert, & Phillips, 1964). In this concept, it is believed that aspects of an individual's problem solving capabilities can be determined. Basically, those people who tend to be less impulsive tend to more completely consider the nature of a problem before taking action (Van Merrienboer, 1990, p. 45). In considering the issue of how problem-solving might affect an individual's success in writing computer programs, no relationship was found between these two factors (p. 50).

Other writers have attempted to link learning style and performance in applications-oriented computer courses where individuals attempt to learn the fundamentals of word processors, spread sheets, and databases. Researchers used Gregorc's Style Delineator to group students into four groups that were based on each individual's learning style: Abstract Random, Abstract Sequential, Concrete Sequential, Concrete Random (Davidson, Savenye, & Orr, 1992, pp. 348-358). Applying classroom performance measures, mixed results came from this study. Two groups (Concrete Sequential and Concrete Random) showed no particular difference in their performance levels. However, two groups (Abstract Random and Abstract Sequential) did show significant statistical differences in the level of their classroom performances. Abstract Random learners performed significantly lower than average and Abstract Sequential learners performed significantly better than average (p. 348).

Another theme sounded by writers related to how learning styles affected the success of students in adapting to Computer Aided Instruction (CAI). In particular, authors have examined whether or not success with different styles of CAI were affected by learning style (Cordell, 1990, p. 175). While the study suggested that teachers needed to make changes in instructional design, no significant effect from learning style was found by researchers in the educational process (p. 179).

A similar study done by Rowland and Stuessy (1988) found that learning style did have an effect on the success and effectiveness of CAI on student learners in the science laboratory. However, the model for learning style used in this research was a comparison of CAI success to whether the student was a holistic or a serialistic learner (p. 36).

Furthermore, some researchers applied the concept of learning style to the general issue of how information system structures are analyzed and designed. In this regard, it has been suggested that individuals with different cognitive styles prefer to have their information organized in varying ways. Therefore, the entire internal structure of information systems should be adaptable to the different needs of people with different learning styles (Cline, 1991, p. 3). This could be achieved by having a number of different internal operating modes built into the design of the system (p. 36). It was also advised that systems designers should consider using tests such as the Embedded Figures Test and the Meyers-Briggs Type Indicator (Coan, 1978, pp. 629-631) in order to determine what different operating modes should be constructed as part of the development process (p. 642).

One major theme in literature relating to learning style and computers related to the use of computers as tools for helping teachers assess and work with differing individual cognitive styles. One researcher demonstrated how computers could be used by teachers to help develop individuals who possess differing elements of Gardener's Multiple Intelligences (Davis, 1991). In this regard, the investigator paid particular attention to how computers could be used to help intelligences (spatial, musical, bodily-kinesthetic, and interpersonal) that are not normally addressed by the educational process.

Sounding a similar theme, others have suggested that microcomputers can be used to aid students with different learning styles during four different phases of instructional delivery. These phases include assessment, prescription, instruction, and evaluation (Chadwick & Watson, 1986, pp. 125-131).

Researchers have even considered the effects of learning style on the level of computer anxiety that people have (Chu & Spires, 1991). Using the Jungian personality types as the cognitive style framework and the Meyers-Briggs Type Indicator as the differentiator, investigators found that personality type did have a relationship with level of computer anxiety. Individuals who were evaluated as Thinking and Intuitive scored lower on the anxiety scale than did Sensing and Feeling individuals (p. 18).

To summarize, researchers definitely have a mixed collection of results in their attempts to link learning style and computing. Several factors could account for these mixed results. First, there are possibly so many dimensions to the human-computer transaction that researchers are not completely sure of what they are actually measuring. Secondly, there are even more dimensions to learning style. Because of this, it is highly possible that researchers have obtained varying results with the changing learning style frameworks that have been applied to the problem.

Human Factors in Computing

The general rubric of "human factors" has been used to describe a wide range of research in the computing field and in related fields. However, as used by computer software designers and the journals that are devoted to the technical aspects of having computers effectively serve human beings, this term usually means the physical and psychological factors that can affect how successfully individuals interact with computers (Marsh, 1990, pp. 16-22).

The journals that address the technical aspects of human factors in software design are typically engineering oriented. Generally, they take existing areas of computing and cognitive theory and try to see how computer programs can be implemented to address these issues.

Cognitive issues in software use are extensively addressed in these journals. However, once again, the theme primarily is the solution of particular problems in particular software systems. For example, a typical research effort focused on how sequences of different possible logical conclusions could be represented and implemented in hypertext software systems (Shum, 1991, pp. 38-40).

In summary, the vast majority of interest by researchers in the area of human factors in computing is ironically on software, the methods for specifying the internals of the software, and the computer itself. Cognitive issues are not extensively addressed, and when they are addressed, it is usually as a subsidiary concept to the primary one of methodology or programming technique.

Computers, Communication, and Culture

The realization that communication with computers is a linguistic act is a relatively new idea. However, the concept of communications and linguistics being a cultural activity that can in turn affect the use of computers in the organization has been present for quite some time.

The cultural aspects of communication have been discussed extensively by a number of writers. The importance of culture in communications is recognized by an anthropologist who stated that,

> The cultural and psychological insight that is important for us to accept is that denying culture and obscuring the effects that it can have on human talents can be as destructive and potentially dangerous as denying evil. (Hall, 1976, p. 7)

This importance of culture in communications was more directly presented with the following,

> Culture is man's medium; there is not one aspect of human life that is not touched and altered by culture. This means personality, how people express themselves (including shows of emotion),