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The interaction of learning styles with learner control treatments in an interactive videodisc lesson on astronomy

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THE INTERACTION OF LEARNING STYLES

WITH LEARNER CONTROL TREATMENTS

IN AN INTERACTIVE VIDEODISC

LESSON ON ASTRONOMY

by

Lawrence Barrett Burwell

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Approved by

Keith C. Wright

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APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro and at the University of Colorado at Denver.

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The purpose of this study was to examine the interaction of different learning styles with different instructional presentations involving learner control while using an interactive videodisc system. Specifically, the issue was to determine if field-independent and field-dependent learners would perform differently from each other under different instructional treatments where the amount of learner control was varied through the environment of interactive videodisc learning.

Learning styles were measured by the Concealed Figures Test, which identified the learner as being either field dependent or field independent. The eighty-seven college students participating in the study were randomly assigned to one of three treatment groups, Program Control, Student Control, or Experimental Control. The Program Control treatment provided the learner limited choices in the pace, path, and amount of instructional exposure. The Student Control treatment provided the learner maximum choices as to pace, path, and amount of instructional exposure. The Experimental Control treatment was a non- interactive videodisc program, consisting of a self-study guide.

Data from the pre-tests, post-tests, and recall tests were analyzed using descriptive methods for means and standard deviations and Analysis of Variances (ANOVAs) were

used for measuring the main effects of the treatments and the interaction effects between learning styles and the treatments of learner control.

The results of the study indicated improvement in learning achievement when using the interactive videodisc tutorial as compared with learning from a printed text containing similiar subject content. There was no significant difference of post-test performance between those students assigned to the Student Control group and the Learner Control group, however, there was a significant difference between the two groups when compared with the Experimental Control group. There were differences of performance between the field dependents and field independents assigned to the three treat ment groups. However, the differences were not significant.

Finally, there was a significant interaction of learning styles, with the treatment groups for learning control, indicating that for the field dependent student, the Student Control method was the better, while for the field independent student, the Program Control method was the best. However, the interactions are the reverse of what was predicted for each learning style. A post-hoc analysis of time-on-task data is used to explain this situation.

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Finally, this dissertation is dedicated to my two children, Jeff and Amy, who will be the beneficiaries of future advances in learning technologies, that are yet to come.

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INTRODUCTION

Introduction

Consideration of individual differences in the learning process has led to a number of studies investigating possible relationships among student aptitudes and different modes of presenting instruction (Behr & Eastman, 1975; Carrier & Clark, 1978; 1968; Eastman & Carry, 1975; McLeod & Adams, 1980; McLeod & Briggs, 1980; Webb & Carry, 1975). Such an approach called aptitude-treatment interaction (ATI) proposes that individual differences be met by different approaches in instruction for students of different aptitudes. The pupose of an ATI design is to investigate whether a given treatment and attribute interact such that the effect of the treatment depends upon the aptitude of the individual (Cronbach & Snow, 1977).

It has long been assumed that individualized instruction that fits the characteristics and needs of learners leads to improved learning. The most effective technologies for delivering individualized instruction is the microcomputer. One of the major contributions of microcomputers to the learning process has been the capability of developing adaptive instruction to fit the various aptitudes and needs of the learner (Park & Tennyson, 1983; Tennyson & Rothen, 1979). However, in considering the fact that students respond differently to different instructional approaches, one must keep in mind that all students' individual differences cannot be addressed with a microcomputer. Materials that stimulate one student may be confusing, distracting, and difficult for another (Smith, 1985). The visual and audio features of computer-generated instruction may help some students in learning a concept, while serving as a distractor to learning for other students.

These issues become increasingly relevant when considering the increasing use of microcomputers in the learning process. Through the application of good instructional design methods, such technology accommodates a wide range of individual characteristics, such as intelligence, prior knowledge, and personality characteristics, including cognitive learning styles. Also, computer-based instruction has some unique attributes--high level of interaction, branching capabilities, rapid judgment capacity, dynamic text and illustration potentials, and learner control over instruction (Carrier, Davidson, Higson, & Williams, 1984; Judd, Bunderson, & Bessent, 1970; Smith, 1984; Tennyson, 1980).

With the addition of the laser videodisc to the microcomputer, adaptative instructional techniques have been enhanced by the random access to a variety of information (video images, audio sequences, variable speed display, graphic, animation) and a high degree of learner interaction (Bork, 1982). Furthermore, the laser videodisc provides the learner with the ability to control the pace, path, sequence, and quantity of information which fits the learner's needs (Gay, 1985; Hannafin, & Colamaio, 1987; Laurillard, 1984; Nugent, & Stone, 1980).

One method of designing instruction to fit individual differences has been that of "learner control". Some students can optimize learning when they are allowed to control the pace, sequence, or style of instruction. Other students function better in a learning situation where control decisions are made for them and they follow a pre-determined path through the instruction.

Researchers have contended that giving the student control over the pace, path, and mode of instruction is instrumental in the acquisition of learning strategies that optimize the student's learning process (Mager, 1964; Mager & McCann, 1961). Other researchers contend that control of the learning situation alone is not sufficient, but that structured advice and assistance is necessary to help the learner develop a learning strategy consistent with his/her needs (Tennyson & Buttrey, 1980).

A frequent topic of research is the relationships between different learner aptitudes and various instructional methods. This research has focused on the concept of cognitive learning styles. The most frequently studied learning style has been that of field dependence/ field independence, which represents an individual's manner in acquiring and processing information. The field dependent person has difficulty in extracting information from the background field in a perceptual or cognitive task and must rely upon external referents, or assistance in developing a learning strategy. The field independent person has less difficutly in perceiving details in a perceptual or cognitive environment and generally relies upon his own internal referents for support in developing a learning strategy (Witkin, Moore, Goodneough, & Cox, 1977).

One of the essential differences between field dependents and field independent persons is the level of guidance needed by the learner, especially field dependent learners (McLeod, Carpenter, McCormac, & Skvarcius, 1978). This level of guidance could be in the form of more explanation to a concept, use of cues to focus attention to details in a text, opportunity for more practice with questions, or advice on how to proceed with the learning task. Providing more guidance for field-dependent learners would fall under the "compensatory" model of providing assistance for skill deficiencies in the learner which will enable them to acquire the necessary knowledge or skills. Letting the field-independent learner work in a less structured environment fits the "preferential" model of presenting information in a manner consistent with the learner's preferred mode of perceiving or reasoning (Salomon, 1972).

Surprisingly, little is known about the interaction of cognitive learning styles and the issue of learner control in a given instructional situation. How will field dependents/field independents perform under circumstances of varying amounts of learner control? Will the field dependent person function better in a situation where they have little control over options of learning stratgies or will they perform well if given control over the learning situation, provided there is adequate advise, help, cues to point the way towards gaining the necessary information? Will the field independent person, because of reliance upon his own internal referents, tend to ignore such advise, help, cues and perform better in a situation where there are various control options available or where there are not control options? Such questions do not seem to be well investigated as evidenced from the lack of information on such issues in the literature.

Even though it is contended that any instructional media, as delievery system, has little impact upon learning (Clark, 1983), little is known about how various attributes of videodisc instruction, such as control, amount of practice, feedback, and other variables affect learning outcomes (Gay, 1985). That lack of information also extends to how students with different learning styles perform with various amounts of control during a computer-assisted videodisc lesson.

Adaptative Computer-Assisted Instruction

As already stated, a principal assumption of the computer's contribution to learning has been its powerful capabilities in adapting instruction to student's individual characteristics and needs (Carrier & Jonassen, 1987). Reasons for this potential are as follows: microcomputer environments are oriented toward individuals rather than groups. Even though small groups can utilize the microcomputer for instructional purposes, the most frequent form of instruction comes from an individualized environment consisting of one student - one computer (Ross & Rakow, 1981).

Microcomputer environments provide maximum flexibility in terms of the quantity of instruction provided and the quality of its delivery. A single program can offer a highly elaborated and information-rich treatment of a topic or a scaled-down leaner version depending upon the needs of the student (Ross & Rakow, 1981). Similarly courseware can provide extensive support for learning in the forms of exercises, examples, feedback and other helps or it can minimize the use of such support elements (Carrier, Davidson, Higson, & Williams, 1984).

Increasingly, microcomputer environments are capable of presenting information in multiple channels, including auditory, visual, and tactile. Furthermore, intelligent video systems provide an unprecedented opportunity to develop new ways of representing information, including multi-media schemes that would mix different presentational forms in whatever ways are most conducive to learning.

Microcomputer environments provide management systems which automate the monitoring of students' progress throughout the instructional process. They can diagnose entry skills, prescribe appropriate content and activities, and continually assess progress toward mastery. Different students then can work on different tasks, managed and monitored by the microcomputer.

Interactive Videodisc and Individualized Instruction

Several researchers have claimed that the interactive videodisc technology provides unique opportunities for developing adaptative instruction (Bosco, 1986; DeBloois, 1982; Hannafin & Colamaio, 1987). Jonassen (1984) states that in essence:

"it (videodisc technology) marries the interactive flexibility of the computer, which enables designers to adapt instruction to meet an almost infinite variety of instructional needs, with the optical videodisc player, which can produce visual presentations in a greater variety than any existing visual display device" (p. 21).

It is this flexibility which makes it especially useful for adaptive, interactive instruction. By adaptive, Jonassen (1984, means:

"the ability to adapt or adjust the presentation sequence or, mode to meet a variety of instructional requirements, such as the learner's instructional needs, prior knowledge, or a host of learner characteristics, such as intelligence, personality or cognitive styles" (p. 21).

Some of the unique characteristics of videodisc that make it a promising medium for teaching are as follows:

1. Interactive videodisc systems provide for various forms of presentation (i.e., rich visuals and audio sequences, graphics and overlay graphics) (Bunderson, 1980).

2. Interaction is a major strength of a videodisc system. Interactive discovery or inquiry approach which requires participation and user control enhances learning, problem- solving, and decision-making skills. Learners can control their own learning sequence, content, forms of representation, speed of presentation (slow motion, fast motion, or still frames), and overall pace (Merrill, 1980).

3. Interactive videodisc can provide immediate and appropriate feedback and reinforcement because material can be presented according to the needs and ability level of

individual learners. The management and recordkeeping capabilities of the system allow for cumulative records to be kept, which encourages individualization (O'Shea & Self, 1983).

4. Because of their vast storage capacity, videodisc systems provide multiple ways to access information including opportunities for realistic practice, multiple examples, problems, exhibits (Bunderson, 1981).

5. The videodisc can add interest, enthusiasm, and motivation due to the intrinsic appeal of visual images simulations, feedback, and individualized instruction (Malone, 1981).

6. Programs can be developed to adapt the instruction to accommodate different learner styles. For instance field independents might be provided with a lesson designed to give them an opportunity to outline or map a course of instruction, consistent with their ability to integrate different bits of information into a pattern, while field dependents could be given a lesson designed to provide graphic organizers, structured overviews of the program, or visual and auditory cues which serve as external supports for learning (Jonassen, 1984).

Considerable research has been published as to the effectiveness and the utilization of interactive videodisc in training and educational environments. Recent research findings relating to the effectiveness of interactive video have generally been favorable (Hannafin, Phillips, & Tripp, 1986; Ho, Savenye, & Haas, 1986; Smith, Jones, & Waugh, 1986). However, in other cases, little or no performance effects have been reported (Dalton, 1986; Meanor & Hannafin, 1986). Much of the research to date has been technology comparison studies where the effectiveness of the interactive videodisc has been compared with other learning systems. Only recently have research reports become available which give some guidance as to instructional design decisions pertaining to interactive videodisc.

Learner Control

One approach to adapting instruction to different learner aptitudes has been to give the learner control over the various options provided in the lesson. Learner control occurs when the the student exercises some measure of control over the sequence, pace, path, and amount of instruction. An alternative approach is external or program control where the student has no control over the direction of the program, but rather follows a paradigm established by the program designer.

Proponents of learner control point to individualization, increased sense of responsibility for learning, and the potential for optimal learning efficiency as support for transferring control of lesson components and/or sequence to learners (Bunderson, 1974; Johansen & Tennyson, 1984; Laurillard, 1984; Merrill, 1975; Johansen & Tennyson, 1984; Steinberg, 1977).

Results of research examining the effects of learner control on performance have been mixed. Some research has indicated that individuals can successfully control their own learning (Campanizzi, 1978; Mager, 1964). Researchers have found that, given advisement, learners can control their own instruction quite effectively (Ross, 1984; Tennyson, 1980, 1981; Tennyson & Buttrey, 1980). Other research has shown learner control to result in ineffective instructional choices (Fry, 1972; Steinberg, 1977).

Research finding have not supported unaided learner control of lesson activities (Steinberg, 1977) when compared with adaptive lesson control or learner control with various forms of embedded coaching of advising (Tennyson, Christensen & Park, 1984; Ross & Rakow, 1981; Tennyson, 1980). Factors such as the nature of the learning task, the age of learners, and the desired learning outcomes of the instruction operate interactively during computer-based instruction (Hannafin, 1984). Other research indicates that subjects may tend to procrastinate more whenever they have control over the pacing of the lesson (Reiser, 1984). Despite these concerns, Snow (1980) has argued that while performance has rarely been optimized under learner control in the past, conditions still warrant study as the effects of learner differences and various instructional strategies.

Cognitive Learning Styles

One of the learner characteristics that has been studied extensively in relation to different instructional treatments has been that of cognitive styles. The concept of cognitive styles refers to an individual's manner of acquiring and processing information. More specifically, it concerns individual differences in the cognitive processes by which knowledge is acquired: perception, thought, memory, imagery, and problem-solving (Ausburn & Ausburn, 1978). These differences describe how people interrelate ideas, the modality in which they prefer to access information, and the sequence in which they prefer to gather information.

Field Dependence/Independence.

The most frequently studied cognitive style has been field dependence-independence. Field dependence/ independence refers to an individual's ability to perceive details as discrete from their backgrounds and to overcome an embedding context (Witkin, Dyk, Faterson, Goodenough, Karp, 1962). An example of such a task is the Embedded Figures Test (EFT) (Witkin, Oltman, Raskin, & Cox 1971) which measures a persons ability to identify a simple geometric figure visually embedded in a complex design. The higher a person scores on the test, the more field independent the individual. Field dependent subjects represent one end of a continuum from field dependents to field dependents Field dependents activities and perceptions are global and tend to focus on the total environment. Field independent subjects are at the opposite end of the continuum; their perceptions are analytical. They are not dominated by the prevailing field.

Witkin et al. (1962) and Witkin and Goodenough (1976) attributed individual differences in visual perceptual problem-solving ability, or restructuring ability, to the tendency to rely upon internal or external frames of reference while problem solving. Field independent persons rely upon internal referents are not easily distracted by the extraneous elements of a visual-perceptual task. They were free to analyze the separate visual elements independently of the context in which they occur. Problem elements were often mentally reorganized to effect a solution.

Conversely, field dependent persons rely upon external referents often perceive the elements of a visual pattern as interrelated which tends to inhibit an analytical response to the task. Field dependents are distracted by the extraneous features of a visual task since they have difficulty in separating such features from the background context. They, therefore, must rely upon external referents for guidance in structuring solutions to a visual task.

In translating Witkin's theory of field dependent-independent styles to ATI research, it has been hypothesized that field dependents would perform better with those instructional treatments where there was more external support in the form of cues, guidance, and advise and that field independents would perform better with those instructional treatments where they could work more independently of any such external support. That is, field dependents would rely more on external explanations for learning, while field independents would rather work independently (Carrier et al., 1984; Kieren, 1969; McLeod et al., 1978; Shulman, 1970).

Need for the Study

Microcomputer-assisted instruction and its latest enhancement, the interactive videodisc, provide unique opportunities for investigating various issues of adaptative instruction. Early research has dealt with various ways in which the technology might be used, and more recent research has been concerned with comparing the videodisc media with other existing media in terms of its hardware features (DeBloois, Maki, & Hall, 1984). Opinions on the uniqueness of interactive video as an instructional technology are varied. DeBloois (1982), for example, has cautioned that interactive video "...is not merely a merging of video and computer medium, it is an entirely new medium with characteristics quite unlike each of the composites."

Despite the volume of research that has been conducted on the comparative effectiveness of the medium of interactive video, and learning, little is known about how various attributes of computer-assisted video instruction such as learner control, amount of practice, feedback, use of cueing strategies for focusing of attention, or the impact of learning styles upon learning outcomes. However, significant research has been reported in a variety of areas which seems likely to generalize to the design of interactive video instruction (Hannafin & Colamaio, 1987). For instance, results like reduced learning time, improved learning performance, and greater retention which have been demonstrated time and time again with CAI might also be demonstrated with the interactive videodisc system (DeBloois, Maki, & Hall, 1984).

In research with computer-assisted instruction and learner control, there is a need to determine if similar results between computer-assisted instruction and interactive videodisc instruction exist. With the videodisc system, the amount of information is greatly increased, more ways are provided for the learner to retrieve the information, and more decisions are provided as how to use it. This in turn, may affect the learner's ability to assimilate, retain, and use it later on (Bunderson, 1981; Gay, 1985).

With respect to cognitive learning styles, the findings have been that field dependents have difficulty in extracting information from a complex background and must rely upon external referent sources to help them structure their experience. Furthermore, they are distracted by extraneous elements within the visual field and must rely upon external sources to help them construct approaches to problem solving or concept learning.

Interactive videodisc environments offer rich visual/ auditory forms of presentation (color, highlighted text, motion, bordering, underlining, sound) which serve to stimulate, motivate, and focus the learner's attention on lesson content and on various learner control options. These control options include menus; Help sections for additional learning; review sections; embedded questions; feedback that is either textual, graphic, or auditory; still/ motion sequences; multi-lingual audio tracks; and glossaries.

The issue investigated in this study is how different learners will utilize such control options in accessing information and in making decisions on how to use it. Will the field dependent person utilize such control options as a support system to their learning needs while field independent people ignores such features and impose their own structure upon the situation?

Purpose of the Study

The purpose of this study, therefore, was to determine if field independent and field dependent learners perform differently under different instructional treatments involving learner control using an interactive videodisc system.

Specifically, the study examined the interaction of field independent/field dependent learning styles with three instructional treatments: program control, student control, and experimental control. The program control treatment consisted of a linear, CAI tutorial design, in which the student progressed from beginning to end of the lesson without the option of branching to different sequences within the instruction, with no additional helps for advisement or reinforcement. The pathway through the lesson was essentially controlled by the computer. Feedback for responses to embedded questions was given in terms of the correct answers when an incorrect response was made.

The student control treatment consisted of an interactive CAI, tutorial designed program in which the student controlled the path, sequence, amount of instruction, the use of options through menu selections. Feedback for responses to embedded questions was given in terms of the correct answers when an incorrect response was made.

The experimental control treatment consisted of a self-study, tutorial guide in which the students assigned to this treatment group reviewed a printed and illustrated text containing the same lesson information as that of the CAI designed treatments. The self-study guide used a frame-based approach to instruction, consisted of the presentation of small units of information, followed by a set of questions and progression to more difficult levels of instruction. The self-study guide offered no suggestions as to how to study a particular lesson, and the student had to look up the correct answer to any questions if he chose to do so.

The content for the interactive videodisc program consisted of selected topics pertaining to Introductory Astronomy. The topics were: Light, Stars, Stellar Evolution. There were twelve embedded practice questions for each of the topic areas. Information with the CAI treatments was presented using either still-frame or motion sequence formats from the videodisc player. Each of the instructional treatments contained a pre-test and a post-test, administered by the computer. Test questions were the same for all treatment groups. The subjects (college students) for the study were randomly assigned to one of the three treatment groups by a process explained in the Chapter III.

The test instrument used to classify students as either field dependent or field independent was the Closure Flexibility (Concealed Figures Test) developed by Thurston (1944) and modified by Thurston & Jeffrey (1965/1980). The

Concealed Figures Test (CFT) is a modification of the Embedded Figures Test and correlations between the two tests have been demonstrated (Elliot, 1961; Gardner, Jackson, & Messick, 1960; Womack, 1979).

The CFT was administered on a group basis and timed for 10 minutes. It required the student to determine whether or not a simple geometric figure is embedded in a series of larger, complex geometric figures. The Closure Flexibility Test measured the ability to hold a mental configuration despite distractions. A high score identified the student as being field independent; a low score identified the student as being field dependent.

Hypotheses

The following hypotheses were tested:

1. There is a significant difference between the mean post-test scores of students assigned to the Student Control treatment group over Students assigned to the Program Control treatment group.

2. There is a significant difference between the mean post-test scores of those students assigned to the Program Control group and the Learner Control group compared with those students assigned to the Experimental Control group.

3. There is a significant difference between the mean post-test scores of field dependent and field independent students in all treatment groups.

4. There is a significant interaction of learning styles with the two treatment groups, Program Control and Learner Control.

Definition of Terms

I. INTERACTIVE VIDEODISC GLOSSARY (Daynes, 1982)

Authoring System: Computer software, utilizing a high-level language that enables a person to design courseware to operate an interactive videodisc program.

Branch: An computer instruction from one sequence in a program to another.

Graphic Overlay: A term used to describe the keying of computer-generated text/graphics onto a color monitor. The overlay is imposed over a video image received from the videodisc player. The timing of the overlay and the display of the video image are controlled by commands from the computer program.

<u>Interactive Videodisc System:</u> The combination of component parts of computer and video necessary for CAI. The component parts consist of a microcomputer, laser videodisc player, laser disc, monitor, connecting cables graphic cards, and software for program development.

<u>Level of Interactivity:</u> The potential for interaction prescribed by the capabilities of videodisc hardware. The three levels of interactivity are:

Level 1: Usually a consumer model videodisc player with still-freeze frame, picture stop, chapter stop, frame addressability, and dual-channel audio, but with limited memory and less processing power.

Level 2: An "industrial" model videodisc player with the capabilities of level 1 plus on-board programmable memory, and improved access times.

Level 3: Level 1 and level 2 player(s) connected to a computer.

<u>Still Frame:</u> Still material including photographs, line drawing, and pages designed and presented as a single videodisc frame.

Chapter II

REVIEW OF RELATED LITERATURE

Interactive Videodisc Systems

Interactive video, the integration of video and computer technologies represents a significant advancement for visual learning and makes possible the creation of a new kind of interactive teaching system. Coupled with the capacity of computers to represent and manipulate graphics, the combination images from the videodisc presents a unique opportunity for the learner to bring these together in form and fashion to suit his learning needs and learning style. Students are able to display video images, graphics, and text, easily and quickly and to use these representations of material to clarify understanding (Deshler & Gay, 1986; Salomon, 1979).

Interactive videodisc combines powers of the micro-computer with the image and audio storage capabilities of the optical laser disc. One side of a videodisc contains the equivalent of 54,000 video still frames or 30 minutes of motion per side. Any single frame can be retrieved within seconds. Interactive video also has the ability to overlay computer-generated text or graphics upon a video image, which gives it greater cueing, highlighting, and explaining potential than almost any existing visual display device (Bunderson, 1980; Jonassen, 1984).

Coupled with the flexibility of the computer, the videodisc enables designers to adapt instruction to meet a wide variety of instructional needs. It has the capability to adapt or adjust the presentation, sequence, or mode to meet a variety of instructional requirements, such as the learner's instructional needs, prior knowledge, content/-task, or a host of learner characteristics, such as intelligence, personality or cognitive styles. Adaptive, instructional designs can be based upon matching models of instruction to learner's needs and characteristics derived form aptitude-treatment interaction research (Jonassen, 1984; Laurillard, 1984).

Applications

Interest in the instructional applications of inter-active videodisc has steadily increased in popularity and in use in schools, colleges, health care institutions, military, and corporate training centers during the past decade. Interactive video is no longer in its infancy as a sibling to the computer, but has matured as a real instructional tool with practical applications (T.H.E., 1987).

The volume of available sofware - both videodisc and micro-computer authoring languages is rising. The Minnesota

Educational Computing Corporation's (MECC) second edition of Videodisc in Education directory, published in February 1987 is 50 percent larger than the first edition, published just nine month's earlier. There are now 400 to 500 available titles on the market, with ten new titles being produced a month as opposed to one or two a couple of years ago (Jones, 1987).

The category of applications to which interactive videodisc has been made over the past several years is continually expanding. Each month educational technology journals and publications bear evidence of this expansion as articles attest to applications in the fields of education, industrial training, military, medical, entertainment, archival/museum, product sales (Kearsley & Frost, 1985; T.H.E., 1987).

Effectiveness of Videodisc

Much of the research to date regarding interactive videodisc, has been comparative studies of the videodisc to other teaching modalities, in terms of time on task, test score gains, and motivation. Bosco (1986) reports on a summary of 29 studies in which interactive videodisc was used for instructional purposes. The majority of the applications were for the military, followed by higher education, and K-12 education.

In sixteen of the twenty-nine evaluations authors drew the conclusion that interactive video was effective. In three of the evaluations, the authors concluded that interactive video was not effective, and in the other 12 evaluations, no conclusion as to effectiveness could be reached. The most prevalent benefits resulting from the studies were on improved user attitude of the videodisc technology over other presentational methods and reduced training time variables. There were fewer studies that measured improved learning performance from using videodisc as a teaching medium.

Studies that showed positive user attitude towards the videodisc technology were reported by (Andriessen & Kroon, 1980; Henderson, 1983; King, 1982; Kirchner, Martzn, & Johnson, 1983). Studies that showed reduced training time as a result of using videodisc were reported by (Bunderson, Lipson, & Fisher, 1984; Davis, 1984; Hull, 1984). Studies that showed improved achievement results were reported by (Gale, 1983; Henderson, 1983; Hon, 1983; Huntley, Albanese, Blackman, & Lough, 1985; Yeany, Helseth, & Barstow, 1980). However, in other cases nominal or no performance effects have been reported by (Dalton, 1986; Gratz & Reeve, 1983; Meanor & Hannafin, 1986; Wilkinson, 1982;). Studies which have compared interactive videodisc, as a teaching medium, with other teaching media, ie, videotape, computer-assisted instruction have shown positive results in favor of the videodisc over other teaching methods as reported by (Boen, 1983; Bunderson, Lipson, & Fisher, 1984; Glenn, Kogen, & Pollak, 1984; Vernon, 1984; Wager, 1984).

Individual Differences and Interactive Video.

In several studies the interaction of background variables such as amount of education, prior training, and age with different instructional methods, including interactive video disc, were explored (Wager, 1984; Wilkinson, 1982; Wooldride & Dargan, 1983). Holmgren, Dyer, Hilligoss, & Heller (1980) conducted a study for the U.S. Army regarding weapons maintenance. In this study, existing training extension course material in film/ slide, and cassette were compared with a videodisc version. The dependent variable was differing amounts of prior knowledge of the subject matter by those participating in the study. The results showed that all groups did about the same and that neither the amount of prior knowledge nor the various presentational methods made any significant difference in the outcomes.

The interaction of cognitive or personality variables with different instructional methods, including interactive videodisc is considered in other studies (Hull, 1984; Yeany, Helseth, & Barstow, 1980). The study by Yeany et al. (1980)

relationship between student of scholastic aptitude and locus of control variables and achievement in the study of genetics.

Locus-of-control is measured by the Rotter's I-E scale (Rotter, 1966) which describes the degree to which an individual believes that reinforcements are contingent upon his/her own behavior. Internal control refers to individuals who believe that reinforcements are contingent upon their own behavior, capacities, or attributes. External control refers to individuals who believe that reinforcements are not under their own personal control but rather are under the control of luck, chance, fate or powerful others. A student, therefore, may approach a learning situation from several different perspectives. He may approach the situation aggressively, confident of his own internal resources to aid him in learning. Or, he may approach it from a more passive position relying more upon external aids to assist him in learning.

In the study by Yeany et al. (1980), students, identified as internally controlled or externally controlled on the Rotter's I-E scale were assigned to either an interactive videotape version of the lesson or labs and lectures. Results showed that the interactive videotape did influence achievement on post-test scores. High scholastic aptitude was correlated to achievement in both treatment groups. However, locus-of-control variable did not contribute significantly to any variations in the outcomes. The researchers conclude that the effects of "externality" in the locus-of-control may have been overcome by the students at the time they reach college level study.

Learner Control and Interactive Video.

Studies investigating the issue of learner control and interactive video have been reported by Laurillard (1984), who investigated the issue of learner control and interactive video in which students were allowed a choice between a computer-driven videotape or an interactive videodisc from which to receive a pre-designed tutorial. Within each teaching medium, the students were given control over sequence of content, choices between exposition and practice, and the amount and timing of practice and testing. It was found that students using the interactive video were more active in making choices as to path, pace, and sequence of instruction than those using the videotape. It was also found that students, using both media, preferred to make their own choices as to sequences of instruction, but needed suggestions as to sequences and strategies.

Gay (1985) studied the effect of prior learning and learner control in the context of videodisc instruction. He found no significant differences on post-test scores for students assigned to the program control treatment, but found significant time-on-task differences of students with low prior knowledge in the program control treatment as compared to the learner control treatment.

Summary

Interactive videodisc represents a new medium, unique from earlier approaches by combining the power of three powerful teaching tools ... books, computers, and videos..to form a medium different from any one of the other three.

Interactive videodisc instruction which is thoughtfully and systematically developed, and shows creative new instructional strategies is beginning to demonstrate positive results, even though earlier results were somewhat mixed. Additionally, research is being conducted with the interactive videodisc to explore further the issues of how computer-assisted learning relates to individualized instruction.

However, no studies have been reported which investigate the effects of different learning styles with different instructional presentations using the interactive videodisc. Nor have any studies been reported which investigate the interactions between different learning styles and different instructional treatments involving learner control within an interactive videodisc teaching environment.

Aptitude Treatment Interactions

Since the mid 1950's Cronbach (1957) has urged researchers to examine the role individual differences play in instructional methods and educational outcomes. With his colleague, Richard Snow, Cronbach coined the term aptitude-treatment interaction (ATI). This research seeks to establish relations between learner characteristics and instructional treatments such that one mode of instruction is ideal for a group of learners with one set of characteristics while an alternate method is optimal for a group of learners with different characteristics.

Unfortunately, ATI research has yielded and continues to yield little in the way of replicable results. Much of the failure of ATI research can be attributed to lack of specificity in the learner, task, and instructional variables selected for study and lack a sound rationale on which to assume that a reliable interaction would occur (Ausburn & Ausburn, 1978; Heidt, 1977; Jonassen, 1982; Salomon, 1972).

Definitions

The term _aptitude_ refers to any relatively stable learner characteristic that may be a predictor of achievement in a given instructional treatment. Examples of some of these variables most commonly investigated include general intellectual abilities, prior learning, personality traits (i.e., cognitive style), motivation, anxiety (Carrier & Jonassen, 1987; Dwyer, 1978; Guilford, 1967; Vernon, 1969).

A treatment is any manipulated variation in the pace or style of instruction that might be expected to interact with a given learner characteristic. A treatment might be a different method of instructional presentation (e.g., self-paced CAI vs. programmed-paced CAI; different types of educational objectives (concepts, rule learning, problem solving); different media production (color vs. black and white); different techniques of organizing the media (e.g., advance organizers, rate of presentation, types of cueing techniques) (Dwyer, 1978).

An interaction occurs when different instructional treatments produce significantly different effects in students with different levels of an aptitude. In the classical experimental model:

> "an ATI exists whenever the regression of outcome from Treatment A, upon some kind of information about the person's pre-treatment characteristics, differ in slope from the regression of outcome from Treatment B on the Same information" (Cronbach & Snow, 1977, pg. 5).

In other words, statistical analysis is used to produce slopes by regressing the dependent variable (outcome variable) on the aptitude variable (Jonassen, 1982).

Types of Interactions

Fundamental to the development of the ATI philosophy is the necessity to produce significant statistical interactions among individual variables and the different treatments. Statistical differences indicate that the slopes of the aptitudes and the treatments intersect at some point on a graph. There are several ways to represent the slopes of these relationships.

Figures 1, 2, and 3 illustrate possible relationships in a hypothetical example between individual learner variable (e.g., level of prior knowledge) and achievement level (e.g., score on criterion test) when identical instruction is presented by means of two different instructional formats - Student Control versus Program Control. A Student Control treatment consists of a program designed to allow the student control over the pace, direction, and amount of learning selected at critical points in the program. A Program Control treatment consists of a program that is virtually linear in nature and provides the student no opportunities to exercise decisions as to the pace, direction, and amount of learning encountered in the program.

Figure 1 serves to illustrate no interaction between treatment type (student control or program control) and level of students' prior knowledge in the content are (high or low). Given two hypothetical groups of students, one group having been identified as low (A) in prior knowledge in a specific content area and the other group (B) identified as high in prior knowledge, assume that the low prior knowledge group (A) is randomly split in half and that one half receives the learner controlled instruction while the other half receives the program control instruction. Their mean scores are plotted as A1 and A2. The high prior knowledge group of students (B) is also randomly split in half with one half receiving the student control instruction and the other receiving the program control instruction. Their mean scores are plotted as B1 and B2 respectively. As is apparent from this hypothetical graph, students who receive the learner controlled instruction perform better regardless of their level of prior knowledge. In addition, the differences in performance between the student and program controlled instruction groups at each prior knowledge level are approximately the same; that is the student control groups (A1, B1) are superior to the program control instruction groups (A2, B2) at both ability levels. Note that the lines are parallel in this example of no interaction between type of instructional treatment and level of prior knowledge.

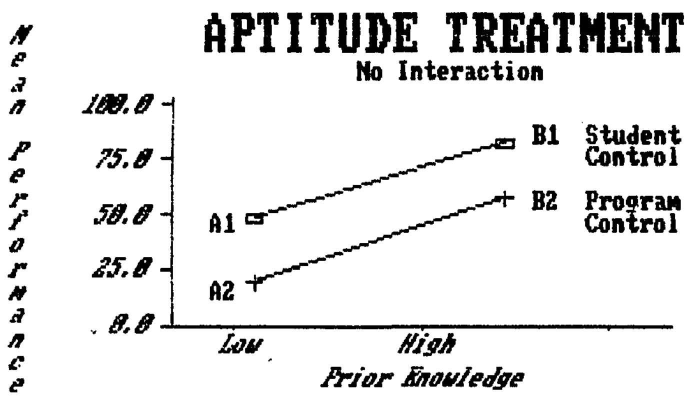

Figure 1 Aptitude-Treatment Interactions

Figures 2 and 3 illustrate cases in which interactions are present. Interactions are evidenced by the fact that the lines in each graph are not parallel. In Figure 2, the learner control treatment is still better overall; that is both low and high prior knowledge students do better receiving the learner control treatment. However, the difference between the student and the program control treatments is smaller for low prior knowledge students and greater for high prior knowledge students. In this situation, there is a difference at each end of the two ability levels. Such a pattern is called an ordinal interaction because one method (student control is still superior at both knowledge levels.

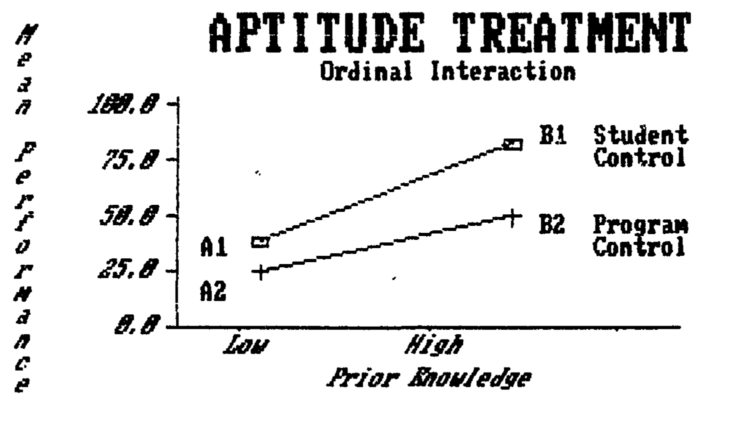

Figure 2 Aptitude-Treatment Interactions

Figure 3 represents the case in which average student performance is about the same for both treatments, ie, if you calculated the means using points A2 and B1 (the Student Control treatment compared to points A1 and B2 (the program Control treatment). However, such a simple description of the results clearly misses the obvious point that for low prior knowledge students the program control instruction treatment produced significant positive results (point A1) whereas high prior knowledge students performed better receiving the Student Control treatment (point B1). This type of pattern is called a disordinal interaction because the order of superiority of the instructional treatments depends on the level of the students' prior knowledge - the program control instruction treatment being best and the Student Control treatment poorest for low prior knowledge students. However, for the high prior knowledge the reverse order is found to exist - the Student Control treatment being best and the Program Control instruction poorest.

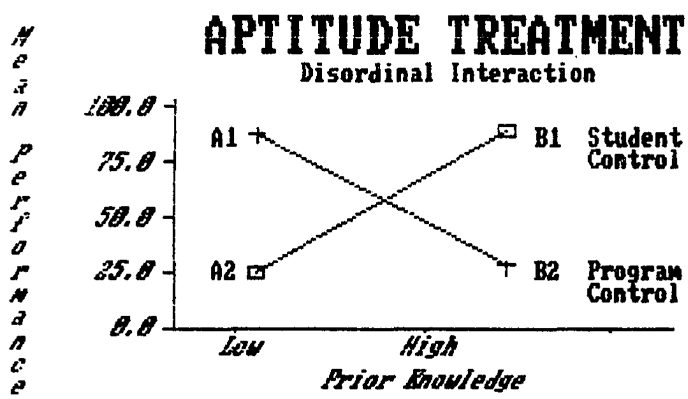

Figure 3 Aptitude-Treatment Interaction

Essentially, aptitude-treatment interactions represent an experimental design. They are similar to a two-way analysis of variance (ANOVA) extended to two or more independent variables, and provides a way of testing for the statistical significance of main effects and interactions. The dependent variable is achievement in one of the three domains (psychomotor, cognitive, affective). The independent variable is the treatment and the dependent variable is the student characteristic. The prime question in ATI research concerns how levels of some treatment interact with the levels of the characteristics of the students.

This really asks three questions: 1) are there differences between the population means of the program types; 2) are there differences between the population means of the aptitude variables; and 3) is there an interaction effect between the aptitude variables and the treatment levels.

Results of ATI Research

Ten years of ATI research were completed before the question was raised as to why the reasonable assumptions of ATI were not generating the anticipated empirical support. Many ATI studies resulted in no significant differences between groups; others which reported interactions proved to be difficult, and sometimes impossible, to replicate under similar conditions (Driscoll, 1987).

Reviewers have offered a variety of explanations, often in the form of criticisms, to account for this lack of consistent findings. According to Jonassen (1982), for example, ATI research has been largely atheoretical. Empirically conceived without a supportive conceptual base, many studies have resulted in a shotgun approach to identifying learner variables and instructional treatments. Tobias (1976) pointed out a problem of researchers' conceptions of "abilities" and "aptitudes". There is not only lack of agreement as to what a given aptitude means, there is inconsistency in the way investigators have chosen to measure it. This being the case, it is hardly surprising that studies have produced conflicting results (Driscoll, 1987).

Other reviewers have noted problems with adequately defining instructional methods being employed as treatments (Tobias, 1981; Jonassen, 1982), and with generalizing laboratory based studies to classroom contexts (Cronbach, 1975; Snow, 1977a; Jonassen, 1982). In their critique, researchers contend that ATI research results cannot be generalized to similar populations or remain valid over long periods of time. So many conditions change with both the test environment and with the subjects in different circumstances and over different periods of time as to nullify earlier results (Brophy, 1979; Cronbach & Snow, 1977; Green, 1980).

Of all the aptitudes studied, general ability (intelligence) has been found to be the best predictor of performance (Cronbach & Snow, 1977). Snow (1977a) defined intelligence as crystallized (conceptual, verbal) or fluid (reasoning, non-verbal) has emerged as the strongest and often the only predictor, sometimes even when it wasn't being measured (Jonassen, 1982). In studies (Crocker, Amaria, & Banfield, 1979) intelligence/aptitude accounted for nearly half of the variance in learning performance. While intelligence is multi-faceted, it usually represents a learning aptidude for performance of school-related tasks (Carrier & Jonassen, 1987).

Understanding that one type of content requires a certain set of mental operations different with another type of content has prompted some researchers to suggest a variation on the ATI approach. Jonassen (1982), for instance, has suggested that content-treatment interactions (CTI) would be more practical and cost effective in terms of the curriculum and product development. Rather than producing a series of instructional methods to match a host of different learner characteristics, "one best method" could be developed and progressively modified to match the information about learner characteristics.

Summary

What this suggests then, even with the past research record of uncertainity about ATI, efforts continue which explore the issues of adapting instruction to fit individual characteristics to different instructional approaches. One such research effort has been the study of the relationship between different learner characteristics and various levels of learner control. A number of research studies have found evidence of particular interactions between learner characteristics and different presentational methods (Wilcox, 1979). An important issue for this study is how will people with certain learning styles behave under different levels of instructional control?

Cognitive Learning Styles

It is generally agreed that learners have different ways of collecting and organizing information into useful knowledge. Correspondingly, it is recognized that not everyone can benefit from the same method of instruction. Educators have sought ways to "individualize" instruction to the needs, interest level, and skills of the learner. While many approaches have been used to determine individual learning differences, no single theory has found widespread acceptance (Danielson & Seiler, 1976). Two concepts however, have been developed to foster an understanding of how people process information: cognitive style and learning style.

The concept of "learning style" appears more recently in the research literature but includes many of the concepts of earlier research in cognitive style. In general, the concept of cognitive style refers to the processes of cognition, which generally include the manner by which knowledge is acquired: perception, thought, memory, imagery, and problem solving (Ausburn & Ausburn, 1978).

Claxton and Ralston (1978) define learning style as the "individual's consistent way of responding and using stimuli in the context of learning". Most researchers and educators treat the term "learning style" as a generic term to include the concepts of cognitive style and student response style.

Description of Cognitive Styles

Cognitive style has not been conceived and studied as a single entity. Rather, a number of different factors have been identified which are used to define cognitive styles. Messick (1966) lists nine cognitive styles that have been studied: independence/dependence, scanning, breadth of categorizing, conceptualizing styles, cognitive complexity/-simplicity, reflectivity/impulsivity, leveling/sharpening, constricted/ flexible field control, tolerance for incongruous experiences. Kogan (1971) adds the risk taking/-cautiousness feature, while Lowenfeld and Brittain (1970) added the visual/haptic perceptual types to the inventory of cognitive styles.

A brief description of a select number of these cognitive styles is as follows:(cf. Ausburn & Ausburn, 1978)

1. Field independence/field dependence:

   Involves the tendency to perceive a perceptual field either analytically or globally; entails the ability to experience items as discrete from their background and the ability to organize the visual information into meaningful learning constructs.

2. <u>Scanning (scanning/focusing)</u>:
Involves the ability to use broad or narrow attention-directing strategies to ascertain items in a stimulus field.

3. <u>Conceptualizing styles</u>:
Involves ability to bring a large number of concepts to bear on a cognitive task; related to the number of distinct conceptual discriminations made on the subject matter).

4. <u>Reflectivity/impulsivity</u>:
Involves tendency, when faced with simultaneous response alternatives, to select either careful delibration and relative certainty of response correctnessor speed of response and high risk of incorect response.

5. <u>Constricted/flexible control</u>:
Involves the extent to which an individual is susceptible to distraction and cognitive interference in tasks containing conflicting cues.

6. <u>Risk taking/cautiousness</u>:
Involves the differences in preference for high

payoff/low probability or low payoff/high probability options.

7. Visual/haptic perceptual types:
Involves the preference for an ability in dealing with visual or kinesthetic sensory input and processing.

Thus, cognitive style refers to a variety of human information processing operations, each of whichcontributes to how the individual learns about his environment and the preferences he expresses towards interacting with that environment (Cosky, 1980). The notion of cognitive style includes two aspects - abilities and preference. Some people deal more effectively with written material than with oral presentation and some people prefer to deal with other modes of information presentation (Kostlin-Gloger, 1978).

Definition of Learning Styles

The most descriptive statement of learning styles can be found in Smith's (1982) Learning to Learn, when he asks,

"what do we mean by style? Some people like to "get the big picture" of a subject first and then build to a full understanding of that picture by details and examples.

Other people like to begin with examples and details and work through to some kind of meaningful construct or way of looking at an area of knowledge out of these details.

Some like theory before going into practice. Others don't." (p.23).

Studies in learning styles initially developed as a result of interest in individual differences during the 1960's, but in the early 1970's, research interests broadened to include group differences such as racial differences, sexual differences, and social differences (Curry, 1983). This change in research focus left the whole field of investigation regarding learning differences fragmented and incomplete, resulting in a vast confusion of terminology and definitions.

In a review of the ERIC literature regarding learning styles, Curry (1983) organized the research on learning styles into three groupings: 1)models of instructional preference; 2)models of information processing style; 3)models of cognitive personality style. A brief explanation of the three models is as follows:

Instructional Preference Model: This model is the individuals' choice of environment in which to learn. It is a concept of students' preference for working at a pace and on material chosen by themselves as opposed to the teacher or a peer group. It is here the learner interacts most directly with the learning environment, learner expectations and other external factors. These are the least stable and the most easily influenced level of measurement in the learning styles inventory list.

The Information Processing Model: This model is conceived as the individual's approach to assimilating and retaining information based upon the classic information processing model (orienting, sensory loading, short-term memory, enhances associations, coding systems, long term storage). An example would be whether better retention occurres if processing generalizations are followed by details, or detailed examples are followed by a generalized principle.

Cognitive Personality Model: This model is defined as the individual's approach to adapting and assimilating information. This adaptation does not interact directly with the environment, but is the underlying and relatively permanent personality dimension. An example of this dimension would be a person's tendency to perceive visual information from a detailed point of view or from a global point of view as is the case with the differences between field independent and field dependent persons.

Field Dependence-Independence

One of the most prominent examples of the cognitive personality model is the field dependent/independent construct Field dependence/ independence has been associated with perceptual-cognitive abilities (Thurston & Jeffrey 1965/1980; Witkin et al., 1971); logical reasoning ability (Limm, 1978; Pascual-Leone, et al., 1978;), social interactions (Witkin et al., 1977); learning and memory (Witkin & Goodenough, 1977).

Field dependence-independence refers to individual differences in preferred ways of perceiving, organizing, analysing, or recalling information and experience. Field dependence indicates a tendency to rely on external frames of reference in cognitive activities, whereas field independence suggests reliance on internal rules or strategies for processing information and the existence of mental restructuring abilities (Witkin and Goodnough, 1977).

Witkin et al., (1977) explain that persons with a well articulated, field-independent cognitive style are apt to analyze actively the elements of a perceptual field when it is organized and to impose structure on a field which lacks an inherent organization. Field independent persons are likely to employ such strategies as analyzing, structuring, hypothesis testing, and inferencing to generate solutions to problems. They appear to experience the details of a "field" as separate elements and they can alter that field or context when necessary to accomplish the task. In contrast, field-dependent persons make less use of these mediational strategies in information processing. They are likely to use the "field" as they find it, to make less use of surrounding information, and to have more difficulty analyzing that information to solve a particular problem

(Readance et al., 1980). In other words, they are not likely to exploit all information sources.

In theory, field dependence/independence may be considered to be one expression of a more general individual difference dimension, defined at one extreme by a global mode of processing and at the other extreme by a more analytical manner of processing (Witkin et al., 1962, 1974). In people with a relatively analytic cognitive style, experiences can be analyzed, and if necessary, restructured through the use of internal referents. By contrast, in people with a relatively global cognitive style, experiences are governed by external referents and dominant organization of the field (Witkin & Goodenough, 1977). Thus the the field independent person takes a more active approach towards analysis and structuring in both perceptual and intellectual activities. The field dependent person, on the other hand, takes a more passive approach at dealing with the field, accepting it as presented with limited analytical and structuring abilities in both perceptual and intellectual activities (Witkin and Goodenough, 1977).

In addition, when learning concepts, global or field dependent individuals will remember the most salient cues, whether or not they are relevant to the concept. When the salient cues are relevant, concept learning is rapid. However, if the salient cues are irrelevant, or if relevant cues are not salient, concept learning will be impaired

(Witkin & Goodenough, 1977). The analytic individual, on the other end of the continuum, can apply a structure or organization to unstructured material and can identify (and as a result, recall) the important cues, whether or not they are the most salient.

Test Measurements.

Researchers have used many different tests to measure field dependence/independence. The tests that were developed by Witkin and his associates were perceptual in nature: First, the Body Adjustment Test (BAT), where subjects are seated in a tilted chair in a tilted room and asked to align themselves with the upright (Witkin et al., 1962). The second Test, the Rod and Frame Test (RFT) required subjects to view a luminous rod centered within a tilted luminous frame and were required to align the rod with the gravitational upright. Those that utilized the external visual field were classified as being field dependent, while those who used the internal referent of their own body were classified as field independent. The third test of field dependence/independence derives from perceptual and intellectual activities. It is entitled the Embedded Figures Test (EFT); a pencil-and-paper test by which subjects are asked to locate and/or break up a complex design in order to locate a hidden figure within the complex figure (Witkin et al., 1971). Many studies have indicated that field independence is a cognitive factor, commonly defined by EFT types of Tests and which, in literature, has been known as disembedding (Goodenough & Witkin, 1977).

Gardner et al., (1960) note other tests which measure field dependency/independency which are as follows: (a) imposition of organization on an impoverished stimulus array, (b) showing conservation in Piagetian tasks, (c) test of conservation, and (d) performance on standard pencil-and-paper tests of spatial visualization. All of these tests have been devised in order to accurately ascertain the learning style as derived from the field-dependence/ independence continuum.

The Closure Flexibility Test (CFT) is an example of another pencil-and-paper test which discriminates between field dependence and field independence. Thurston & Jeffrey (1965, 1980) developed the Closure Flexibility (Concealed Figures Test), which required the subject to determine whether or not a simple geometric figure is embedded in a series of larger, more complex geometric figures. This perceptual test was developed on the same Gottschaldt figures as was Witkin's Embedded Figures Test. The Closure Flexibility test measures the subject's ability to hold a mental configuration despite distractions. A high score identifies the subject as being field independent, while a low score identifies the subject as being field dependent.

Relationship of Learning Styles to Learning

What impact do these differences in characteristics between field dependent/independent persons have upon learning in general? The dimension that seems to be most important is the level of guidance required by the learner (McLeod et al., 1978). Field dependent students respond better when there is more explanation provided by the teacher; or by the learning situation, i.e., computer-assisted instruction; where the subject matter contains relevant cues to direct the learner's attention to the material to be learned; and where the learner is not distracted by competing advice or irrelevant cueing strategies. Field independent students are more adept at working independently and making discoveries without much assistance; are not distracted by irrelevant or competing cues; and are able to impose their own structure upon materials for effective storage and retrieval of information (Ausburn & Ausburn, 1978).

For years, researchers have studied the relationship of different learning styles with different learning tasks and different instructional methods. Such studies fall under the heading of aptitude-treatment interactions begun in the 1950's and continuing until the present time. Research in aptitude-treatment interactions proposes that students of one particular learner characteristic (aptitude) learn better with a certain instructional method (treatment), while students with another characteristic learn better under a different instructional method.

It is to the topic of the interactions between personal aptitudes and different instructional presentations (treatments) that this discussion now focuses.

Learner Control

Learner control is a feature of instructional design whereby the learner can direct the flow of instruction provided by the system, thus guiding the system to respond to their own needs and interests as he/she perceives them (Duchastel, 1986). This is based on the premise that rather than the instruction controlling the learner, the learner be allowed to adapt to the instruction by making choices which places control in the hands of the individual (Merrill, 1975). Learner control over aspects of instruction has been viewed as a means of doing this.

Under instructional systems that emphasize learner control, individuals may learn to control and process information in a variety of situations, rather than becoming dependent upon instruction that allow the learner few choices as to the direction, sequence, amount and timing of instructional events. When learners make conscious choices concerning their instructional path, they may process more of the information themselves and process it more deeply

(Bruner, 1961). There is some evidence that giving learners increased control over their learning will help them develop "the capacity for independent regulation of their own mental processes and behavior" (Landa, 1976, p.8). Other research studies have shown that feelings of self-efficacy and self-determination, and the skills involved in taking independent responsibility are enhanced by learner control (Bruner, 1966; Lawier, 1982; Papert, 1980).

While many assertions have been made that the learner controlled method can accommodate individual differences in initial aptitude (Bunderson, 1980; Hartley, 1966; Merrill, 1980), results from studies in learner control research have been contradictory (Judd, 1972; Steinberg, 1977). In most studies, students actually learned less when they had control over their own sequencing and instructional strategies (Judd, 1972). In those studies which have found positive advantages for learner control, the subjects have been highly motivated and/or intelligent and might be expected to do better under less structured conditions (Fry, 1972; Judd, 1975; Tennyson, & Rothen, 1979).

Although results of research examining the effects of learner control on performance have been mixed, some research has indicated that individuals can successfully control their own learning (Campanizzi, 1978; Mager, 1964). Other research has shown learner control to result in effective instructional choices (Carrier, et al., 1984; Fry, 1972; Steinberg, 1977). And Clark (1980) points out, what a student prefers in the form of control is not necessarily what is best for that a particular student. A low performance student may select the path of least resistance through a lesson, when in fact, he should utilize fully the options for additional learning that may be designed into the lesson. Finally, Tennyson & Buttrey (1980) have found that, given advisement on control options and learning strategies, learners can control their own instruction quite effectively and make significant gains in learning.

Learner Control Strategies

Learner control is a function of those options designed into the lesson which allow the student various degrees of freedom in accessing information, pacing through the lesson, and making decisions about the amount and type of instruction received. Typically, instructional control has been examined by manipulating instructional features such as method of lesson pacing (Ross & Rakow, 1981); management and evaluation decisions in instruction (Hannafin, 1981); en route decisions regarding need for additional instruction (Tennyson, 1981).

Learner control can be thought of as a continuum ranging from full external control to complete internal control. Instruction is considered to be more externally controlled with fixed rate, linear delivery systems such as slide-tape presentations. Learner control is involved in a system which permits the learner to select to study one topic before another, or to invoke a help command when uncertain about how to proceed, specify the number of questions to be answered, or to request extra examples of a concept being studied (Hannafin, 1984).

Research Findings on Learner Control

Research findings on learner versus system control have been varied. In Tennyson & Buttrey's (1980) research, total learner control conditions have consistently yielded lower post-test performance than system control, partially because subjects in learner control conditions terminate the instruction too early. When allowed to choose the difficulty of arithmetic practice problems in a CAI lesson (Fisher, Blackwell, Garcis, & Green, 1975), elementary children chose problems that were too easy or too difficult. Alternatively, Judd, Bunderson, & Benssent (1970) found that college students were good judges of the amount of practice they needed. Lahey & Crawford (1976) gave Navy students the freedom to choose from among 16 possible strategies while studying content in electronics. They observed that most students used only three of these strategies consistently.

Learner control can also vary according to the subject content of the instruction (Gagne & Briggs, 1979). Procedural tasks are best taught using program control. When a sequence of steps or tasks must be learned, the order among the steps must be controlled. Verbal learning tasks are best taught using program control. When verbal information is to be taught, the need for exactness of presentation is needed. Program control is more effective for unfamiliar learning tasks and learner control more effective for familiar learning tasks (Ross & Rakow, 1981; Tobias, 1981). Lower-order intellectual skills, such as simple discriminations, concepts, and rules are best taught using program control. Higher-order skills, such as problem solving are best taught using learner control.

Hannafin & Colamaio (1987) studied the effects of various interactive video instructional control options and practices on learning. College-age students were assigned to three treatment groups with varying amounts of instructional control: (1) designer imposed responses to embedded questions; (2) learner selected pathways; (3) strict linear control. On post-test scores it was found that students from treatments that allowed some form of learner control did better than those students from the treatment group that was strictly linear. The effects were greatest for factual learning and least influential for procedural learning.

These studies demonstrate that the effects of learner control may vary across the age level of the subjects, the type of content taught, and the specific nature of the options allowed (Hannafin, 1984). While learner control has proven less successful, Snow (1980) has argued that performance has rarely been optimized under learner control in the past, but the conditions of effective learner control still warrant study.

To this end, a variety of "advisement" procedures have been studied (Ross & Rakow, 1981; Tennyson & Rothen, 1979). Researchers have successfully developed procedures that offer guidance upon which individual learners's decisions can be based. Learners may be advised as to the number of practice items or examples recommended, based upon the learners's past, current, or cumulative performance, during a lesson. However, the learner maintains control over the instructional decisions by accepting or rejecting the advice offered during the lesson, and proceeding as individually deemed appropriate. When coaching or advisement was introduced in the form of feedback subjects in the learner control condition did as well as those under adaptive control conditions (Tennyson & Buttrey, 1980).

Learner Control and Individual Differences

Snow (1980) argues that although, in general, learner control has not produced optimal performance, it is important to investigate further what types of learners should be granted control and under what conditions. If certain abilities or personality dimensions predict performance under learner control, students could be differentially granted decision- making power as they move through an instructional sequence. For instance, what happens to the issue of learner control when you add to the research considerations of prior knowledge, personality constructs such as locus-of-control or the cognitive learning styles? Do the differences in the amount of prior knowledge or the expectancy values of locus-of-control or the information processing of various learning styles impact significantly with the issues of learner control?

Prior Learning.

Snow (1980) argues that learners differ with respect to how well they (a) like self-control over events within instruction, (b) will perform under such conditions, and (c) will use their skills in executing such controls. Several studies provide support for these hypotheses. Ross & Rakow (1981) found an ordinal interaction involving level of prior knowledge and the control variable. In their study, students with low prior knowledge profited from a computer-controlled sequence. No differences for control were found for students with high prior knowledge. These findings support Tobias' (1981) work on the relationship of prior knowledge to instructional support. His research consistently has found that the less familiar the student is with the content of the unit to be mastered, the greater the need for support in the form of clearly stated objectives, explicit highlighting of important points, the requirement for overt responding, and other guidance devices.

Interactions of Learner Control and Locus-of-Control.

The personality variable, locus-of-control, is measured by the Rotter I-E Scale (Rotter,1966). Persons who score low on the I-E scale are said to have internal locus-of-control and are thought to attribute events in their lives to their own decisions and actions. On the other hand, persons who score high on the I-E scale are considered to possess external locus-of-control and supposedly attribute events in their lives to outside forces or luck. Because internally-oriented students tend to see themselves as being responsible for their learning, they probably prefer to make their own instructional decisions and are careful in making those decisions. However, because externally-oriented students tend to regard external factors as being responsible for their learning, they probably prefer to let teachers and sytems make instructional decisions and, should such decisions be forced upon them, they are not likely to exercise much care in making their choices. Therefore, greater learner control should facilitate learning for internally-oriented students while lesser learner control should facilitate learning for externally-oriented students.

Parent, Forward, Canter, & Mohling (1975) randomly assigned fifty-four college students, identified as to their locus-of-control factor (internal or external) to two treatments in which they received a two-hour, mini-course on computer programming. In the high discipline treatment, the teacher laid down the rules and lectured. Thus the sequence and pace of the instruction were controlled by the teacher. In the low discipline treatment, each student was given an instructional booklet and told to study it as he/she desired. The teacher merely answered questions. Nether treatment or locus-of-control produced significant main effects in post-test performance. But, when the post-test scores of students from the upper-and lower-third of the locus-of-control distribution were analyzed, a significant ($p < .05$) treatment by locus-of- control interaction was obtained. This indicated that the learning of one student is affected differently than the learning of another student by the unique characteristics of the different instructional methods.

<u>Learning Style and Learner Control</u>.

Another approach to examining the influence of individual differences on learner control was carried out by Carrier et al. (1984). They investigated how field independent and field dependent children behaved when given opportunities to select optional instruction elaborations in a computer-based concept lesson. In addition to receiving a core lesson, students in the "options " treatment were allowed to select various instruction elaborations such as paraphrased definitions of concepts, additional expository examples, additional practice items, and analytical feedback when learning four coordinate concepts dealing with propaganda techniques. In the two contrasting treatments, students received either the core instructional lesson only or the core lesson plus all possible instructional elaborations. These two versions ere labeled "lean" and "forced" respectively.

The authors predicted that students who had field dependent styles would show different patterns of performance than those with field independent styles. Because field independent learners have been shown to be more assertive in learning new concepts, it was expected that these learners would take advantage of the options and thus learn more from this treatment than the more passive field dependent learners. However, the expected interaction between the cognitive style variable and the treatment did not occur. Field independents outperformed field dependents in all of the treatments. The pattern of scores suggested that field dependents did profit more from the structure of the Forced Treatment than the self-imposed structure of the Options Treatment, but this interaction did not reach statistical significance.

Summary

Research, thus far, has not completely demonstrated the case in behalf of learner control except under special circumstances. Many variables affect the issue such as type of learner, age of learner, the type of lesson content, the amount of prior knowledge of a subject matter, and the nature of the control strategy, such as advisement, being used.

With computer-assisted instruction the issues of learner control become an important design issue. The capability of the computer to judge, to adapt, to provide feedback, to implement options based upon learner input, and to provide advisement on how and when to use those options and feedback as to performance creates the milieu in which learner control takes place.

The addition of the videodisc to the microcomputer enhances the possibilities of learner control by providing vast amounts of information of a kind that is different from that provided by the computer (Laurillard, 1984). As the amount of information increases, so do the number of way that it can be put together by the student, who is controlling the amount and sequence of instruction.

However, students react differently when given the option of control over learning strategies. Some students will utilize the options of control as a means of assisting them in their learning, while others will bypass control options and formulate their own patterns for learning. One of the essential differences between field dependents and field independents is the level of guidance needed by the learner, with the field dependent person relying more on guidance in the form of additional explanations, attention to cueing systems, and accessing to opportunities for additional practice and reveiw of subject matter.

It is the difference in the way in which students, particularly the field dependent/independent person utilizes learner control strategies that forms the basis for this study. The focus of the study is to investigate the interaction of learning styles, field dependency/-independency with instructional treat ments of learner control.

CHAPTER III

METHODOLOGY AND PROCEDURES

Study Design

Subjects

This study was conducted in the Physics and Astronomy Department of the University of North Carolina at Greensboro. The 87 subjects for this study came from two classes within the department: 76 students came from an Introductory Astronomy class, and 11 students came from an Introductory Physics class.

Before participating in the study, each student was required to complete a Consent Form to participate in the research project. In addition to informing the student about the nature and purpose of the study, information was collected about the student's standing in school, major field of study, and previous coursework in astronomy.

There were 37 females and 40 males included in the study. The majority of the students from the astronomy class were non-science majors, who were taking the class to fulfill a general science requirement for their particular major. All of the students from the physics class were either science or math majors. Only two students had any previous coursework in astronomy and in each case, more than a year had elapsed since completion of that coursework.

Participation in the study was voluntary. Extra credit was granted to those students who completed all phases of the study.

Hardware/Software

The computer workstation used in this study consisted of a Zenith microcomputer with 640 K internal memory and two floppy disks, and a Zenith (ZVM-135) high resolution color monitor. The computer was equipped with a Color Graphics Adapter (CGA) card and a PC Microkeyer with a a graphics overlay board and control pod that controlled the video from the player onto the PC and back out to the monitor. This allowed for overlaying of text and graphics onto the video image displayed on the color monitor.

The computer was interfaced with a Pioneer LDV4000 videodisc player. The videodisc used in the study was the "Astronomy" disc from the Space Science Series of videodiscs published by Video Visions Associates under the sponsorship of The Center for Aerospace Education. Various frames and motion sequences from this videodisc were edited into the lesson design and displayed upon computer command onto the color monitor. These frames and motion sequences are described in later sections of this chapter.

The software used to develop the instructional sequences for this study was an authoring system, "Quest", which was developed by Allen Communications of Salt Lake City, Utah. "Quest" is an integrated authoring system that allows the designer to create instruction and computer-based instruction with little knowledge of computer programming.

Features of the "Quest" authoring system include:

A. Prompt Lines. "Quest" provides a constantly-visible menu and a series of sub-menus of prompt lines which allows for the creation of text and graphics within a frame-oriented design.

B. Information Presentation. Quest provides:

- text fonts come in multiple sizes and color, and provides the ability to create text fonts of one's own design.

- graphics design include standard and custome-designed shapes, plus the moving, mirroring, animating, scaling and rotating of any graphic or graphics-text segment.

- video control of all major videodisc players to include full editing control and the overlaying of computer images on video frames.

- audio sequences.

C. Answer Processing and Branching. "Quest" provides the designer with such features as extra words, phonetic spelling, character-by character analysis, numeric tolerances, as additional latitudes for answer analysis. Additionally, there are 10 available branching options which permit movement within and among lessons using only simple frames names.

D. Author Management. Along with real-time editing options, "Quest" allows the designer to print out lesson display frames and performance information, and to check lesson structure for inconsistencies.

E. User Management. "Quest" supplies a complete set of management functions to include cataloging lesson, registering students and assigning lessons, reporting on student performance and a testing mode that allow the designer to create a pool of questions that "Quest" then draws from randomly.

Instruments

Closure Flexibility (Concealed Figures) Test

The test instrument that was used to identify the students' perceptual and cognitive style of field dependent or field independent was the Closure Flexibility Test

(Concealed Figures Test), developed by Thurstone (1944) and modified by Thurstone &, Jeffrey (1965). Closure Flexibility is one of a series of tests designed to establish a profile of scores on various basic primary abilities. The mental ability that it measures is what has been identified by Thurstone (1944) as the "second closure factor." This factor is defined as the ability to hold a configuration in mind despite distraction. It is the capacity to see a given configuration (diagram, drawing, or figure) which is "hidden" or embedded in a larger, more complex drawing, diagram, or figure.

The Closure Flexibility Test (Concealed Figures), modified again by Thurstone &, Jeffrey (1980) and published by London House, is a 10 minute, timed, paper-and-pencil test which can be administered individually or to groups. The test consists of two parts: one page of directions with three practice questions and seven pages of test (49 items). Students are not expected to complete all 49 items within the time allotted for the test. Each item consists of a figure, presented on the left of the page, followed by a row of four, more complex drawing to the right. Some of these four, more complex, drawings contain the given figure in its original size and orientation. Instructions are to look for the original figure in each of the complex drawings and to put a check mark ( ) under each drawing which contains it and a zero (0) under each which does not.

The score on the Concealed Figures Test is the number of correct answers minus the number of wrong answers. This scoring formula is written S = R-W and represents the usual correction for guessing (Baehr, 1965). Those scoring high on the test are field independent; those scoring low on the test are field dependent. Since there are seven test items to a page and each test item has four answers, there are 28 answers to each page. The maximum raw score is the total number of pages (7) times the total possible score for each page (28) which equals 196.

The raw scores are converted to normalized standard scores, derived from the scores of previous takers of the test. The total range of normalized standard scores falls between 0 and 100, with a mean or average of 50. For the purpose of this study, those students obtaining a standard score below 50 were classified as field dependent, (difficulty in overcoming the embedding effects of the complex figure upon the simple one), while those scoring above 50 were classified as field independent. This method of differentiating field dependents and field independents is recommended in the Test Manual from London House. The same method has been used in studies where the CFT was the test instrument to identify field dependency in order to assure the groups would be composed of both high and low differentiators (Courtier, Wattenmaker, & Ax, 1965).

Test Development.

A large body of experimental literature has demonstrated significant relationships between the individual's attitudinal, motivational, or emotional characteristics and his performance on perceptual or cognitive tasks (Blake, & Ramsey, 1951; Bruner, & Krech, 1950; Witkin, Lewis, Hertzman, Machover, & Meissner, 1954). Of the factors identified in research studies of perception, two that have proved particularly fruitful in personality research are speed of closure and flexibility of closure. The first involves the rapid recognition of a familiar word, object, or other figure in a relatively unorganized or mutilated visual field. Flexibility of closure requires the identification of a figure amid distracting and confusing details.

The ability to hold a configuration in mind despite distraction has been identified in a number of factorial studies beginning with Thurstone's (1944) exploratory study of perception In this study, a large battery of perceptual tests was administered to 194 undergraduate students. Included in the battery were the original Gottschaldt Figures, an early form of the present test. On the basis of preliminary experiments with this test, Thurstone felt that the simpler figures involved different functions than did the more difficult figures. The test was therefore divided into two parts called A and B, and each part was scored differently and separately to emphasize the distinction between the functions involved. The score for Form A was based on the number of figures correctly marked within the time allowed, while the score for Form B was based on the number of figures correctly drawn per minute of time.

Both forms of Gottschaldt Figures proved to have significant loading on each of two factors which Thurstone called "A" and "E." Upon examination, Thurstone suggested that Fact "A" might be most representative of the ability to hold or form a perceptual closure despite some distraction and that the ability is best represented when the subject just forms the closure in the face of some distraction. Factor "E" involved the manipulation of two configurations simultaneously or in succession, in other words, flexibility in manipulating several more or less irrelevant or conflicting gestalts.

Since both forms of Gottschaldt Figures showed similar factorial content, Thurstone recombined them into one form in which each of the 18 items consisted of a stimulus figure and four complex designs.

In a study of the speed and flexibility of closure factors, Pemberton (1951) administered a new form of Gottschaldt Figures to 154 college students. This form of the test, called Concealed Figures and devised at the Psychometric Laboratory, The University of Chicago, is longer than the test previously called Gottschaldt Figures.

Pemberton found in this study that the Concealed Figures test had the highest loading (.53) on a factor she described as the second closure factor or "closure flexibility." Finally, Pemberton (1952) in a test with temperament found that subjects who scored high on this trait are more likely than those who score low to describe themselves as socially retiring, not dependent on social conventions, having theoretical interests, and having a drive for achievement.

Reliability and Validity.

The reliability measure of internal consistency is reported by Thurstone as being .78 in a split-half reliability coefficient, whereas Pemberton (1951) reported a corrected split-half reliability of .94 on the present form of the Concealed Figures Test.

Yela (1949) reported .49 coefficient between reasoning factor and perceptual factors. Thurstone (1949) in a study of mechanical aptitude found correlation of .63 between the inductive reasoning and the flexibility of closure factors. Botzum (1950) reported .64 coefficient for analytic reasoning factor. These studies indicate that closure flexibility is related to mechanical aptitude and certain kinds of reasoning.

Relationship to Field Dependence/Independence.

The flexibility of closure factor has been shown to be highly related to the field independent perceptual-cognitive dimension. This factor which Witkin, et al (1962) described as a dimension of consistent individual differences in the ability to separate items from a configuration containing competing cues. This ability has been shown to be characterized by the person who ..

"actively attempts to master and reorganize the environment and strives for independence, leadership, special skills, and competencies (Elliot, 1961),

In one investigation (Pemberton, 1952) found persons who excelled in speed of closure tended to rate themselves as sociable, quick in reactions, artistic, self-confident, systematic, neat and precise, and disliking logical and theoretical problems. In contrast, those scoring high in flexibility of closure had high self-ratings on such traits as socially retiring, independent of the opinions of others, analytical, interested in theoretical and scientific problems, and disliking rigid systematization and routine.

A number of studies (Schwartz, & Karp, 1967; Phillips, 1957) have shown this version of Gottschaldt Figures to be very highly correlated with embedded figures, another test of field dependence (rs range from .46 to .77). Although field dependence was initially identified as a perceptual style, research has led to the conclusion that this capacity is not limited to the perceptual mode but represents a generalized analytic orientation (Faterson, 1962; Witkin, et. al., 1962). However, the dimension of field dependence appears quite similar to the factor of flexibility of closure isolated by Thurston in several factorial analytic studies. Several studies (Elliot, 1961; Gardner, Jackson, & Messick, 1960) have reported high correlations between measures of field independence and Thurstone's Concealed Figures Test (CFT) which is a measure of flexibility of closure. Witkin, et al. (1962) explicitly acknowledged this relationship and stated that "..flexibility of closure...and field dependence may be different names for the same dimension" (p. 52).

Dickstein (1968) used the CFT in a study of field independence and performance on concept-attainment tasks where the material contained several perceptual attributes of color, shape, underlining and highlighted text. It was found that field independents made fewer choices for additional instruction than field dependents and relied less on the visual attributes for assistance in learning the material.

Daugherty, & Waters (1969) studied field dependency and student leadership on a college campus. It was hypothesized that field independent students were more likely to be campus leaders than field dependent students, since, according to the CFT, field independents have a high drive for achievement. The results of the study were in the predicted direction, though not to an extent to give statistical support to the hypothesis.

Wormack (1979) studied field dependents/independent students in a visualization task and achievement in a physics class. Wormack used the Concealed Figures Test and the Hidden Figures Test to identify learning style. The results of the study confirmed that persons (field dependents) with high visualization and low on flexibility of closure scored lower on achievement than field independents with low visualization and high flexibility of closure.

Smith (1985) studied the relationship of microcomputer-based instruction and field dependency/independency as measured by the Concealed Figures Test. It was found that field independents performed better than field dependents when it came to visually locating relevant material in the lesson. Field independents were less confused and distracted in their visual location tasks. This is consistent with their ability to disembed a simple figure from a complex background.

Dependent Measures

Pre-test.

All subjects in the three treatment groups took a pre-test, consisting of 16 randomly ordered multiple choice questions which tested for prior knowledge of information and procedures, as well as problem-solving capabilities within the subject matter realm of astronomy. The test was administered on the microcomputer for all students, including the control group. Feedback was provided to any incorrect answers of the questions.

Results from the pretest were used to establish equivalency criteria for the students participating in the study. That is, to determine if all of the students arrived at the study with approximately the same amount of prior knowledge of astronomy.

Table 1 represents data about the number and type of frames developed for the pre-test by type of questions and level of processing elicited by each question. The processing levels range from simple recall of information, problem solving, or performance of a procedure within a computer-assisted context. Since the computer program is limited to recognizing right/wrong type responses, the designer cannot test for higher level of learning skills such as analysis or synthesis.

Table 1. Number and Type of Questions by Level of Processing for Pre-Test

Question Type	Total Questions	Total Frames	Level of Processing: Recall	Problem Solving	Procedure
	16	45	11	4	1
Telescopes	2	4	2		
Nuclear Reaction	2	6	1	1	
Spectra	2	5	2		
Electro-Magnetism	2	6	2		
Stellar Magnitude	1	5		1	
Graph Reading	2	4	1	1	
Stellar Evolution	1	5	1		1
Stars	2	6	1		
Wavelengths	2	4	1	1	

As shown in Table 1 the most frequent type of question was the simple factual recall question. An example of two of the pre-test questions is repoduced below. The student was allowed only one attempt to get the correct answer. Feedback was given on all questions as to whether the response was right or wrong and the correct answer was supplied in the case of any incorrect responses.

Pre-Test Questions.

Two of the pre-test questions are reproduced below.

1. Characteristics of a star such as its chemical composition:

1. Can be measured and stated in specific terms;

2. Can only be guessed at, since there are no instruments to take such measures;

3. Cannot be measured, since stars are too far away;

4. None of the above.

Type 1, 2, 3, Or 4 _______ and Press Enter

2. In the Milky Way Galaxy where is our Sun located?

1. In the center;

2. On one of the spiral arms;

3. In the halo;

4. None of the above.

Type 1, 2, 3, or 4 ______ and Press Enter

In the feedback frame to this question frame, there is a graphic representation of a rotating galaxy, with an explanation that our Sun is located on one of the spiral arms of the galaxy.

Post-test.

The dependent measure was a 20 question, computer-administered post-test given at the completion of the tutorials to all students, including the control group. The questions tested for knowledge of the information, procedures, and problem-solving skills encountered during the computer-assisted tutorial or self-study guide on "Astronomy" by Moche (1981).

The student was allowed only one attempt to obtain a correct answer. Feedback was given on each question to let the student know that he/she had obtained the correct answer or in the case of an incorrect answer, the correct answer was made known to the student by the computer.

Table 2 presents data regarding the number and type of frames developed for the post-test questions by type of question and level of processing elicited by each question. The processing levels range from simple recall of information, problem-solving or performance of a procedure within a computer-assisted context.

Table 2. Number and Type of Question by Level of Processing for Post-Test

Question Type	Total Questions	Total Frames	Level of Processing: Recall	Problem Solving	Procedures
	20	28	14	5	1
LIGHT	6	6			
Wave Lengths			2		
Spectrum			2		
Color				1	
Electromagnetism				1	
STARS	8	13			
Spectral Class			2		
Magnitude			1	1	
Color			1		
Temperature			1		
Brightness			1		
H-R Diagram				1	
STELLAR EVOLUTION	6	9			
Protostar			1		
Helium Flash			1		
Planatary Nebula			1	1	1
Evolutionary Track					
Red Giants, White Drarfs			1		

The number of type of questions (recall, problem solving, procedural) equals the total number of questions. The predominant type of questions were information recall questions, which represent the lowest level of information processing available within the learning context.

Examples of Post-test Questions.

Two examples of the questions used on the post-test are given below. Examples of the other questions are provided in the Appendix.

1. Four Nearby Stars

Star	Apparent Magnitude	Absolute Magnitude	Spectral Class
1. Rigel	0.1	-7.0	B
2. Sirius	-1.5	1.4	A
3. Barnard' Star	9.5	13.3	M
4. Canopus	-0.7	-4.7	F

Match The Following for Each Star.

Type 1,2,3,Or 4

A. Hottest ----   C. Faintest Appearing ------

B. Coolest ----   D. Really Brightest ------

Use the < > Arrow Keys to Move Cursor & Press Enter

2. Match the following definitions.

1. White Dwarf	----Star that changes periodically in size & brightness
2. Helium Flash	----Star that has blown its hydrogen shell
3. Planetary Nebula	----Star, which is small and dense and is below the Main Sequence on the H-R Diagram
4. Variable Star	

Type 1, 2, 3, or 4
on the spaces. Use
Arrow Keys, Press Enter.

Retention Test.

One week following the completion of the videodisc exercise and the post-test, a pencil-paper retention test was given to each student participating in the study in order to determine short-term information retention. The reason a pencil-paper type test was given rather than a computer-assisted videodisc version was due to the fact that there was only one videodisc system available for the study and it was in constant use by those students taking the original tutorial on a schedule which lasted for eight weeks. It would have been impractical to have waited until the end of the eight-week period before beginning any retention testing of the students.

The retention test consisted of 10 questions, 7 of which had multiple answers, designed on the same format of the computer-assisted videodisc versions. Questions that had graphics were of the same order and style of the video-disc versions. All of the questions tested for simple factual recall of information. A copy of the retention test is included in the Appendix of this document.

Instructional Content

The instructional content for the treatment phase of the study consisted of three lessons on subject matter pertaining to Introductory Astronomy. The lessons were: Light; Stars, Stellar Evolution. The lessons were designed around the subject matter contained in a self-study guide titled "Astronomy, 2nd. Edition, A Self-Teaching Guide" by Dinah L. Moche (1981). Permission was granted by the publishing company, John Wiley & Son, Inc. to used the study guide in the study, to reproduce relevant sections for distribution to subjects involved in the study.

The videodisc used in the study came from the series of "Space Disc" published by Video Visions Associates, Ltd. under the sponsorship of The Center for Aerospace Education, Drew University. The "Astronomy" Disc was used in the study and relevant frames, both still and motion sequences were used.

A total of 30 practice questions was embedded in the three lessons. In order to provide en-route practice of lesson content, the questions were distributed among factual information, procedural steps, and problem-solving applications. The majority of the questions were of the factual information recall processing level. Review frames and questions were provided at the end of each of the three lesson segments.

Table 3 describes the number and type of frames for each of the three lessons.

Table 3 Number and Type of Frames by Lesson/Content

LESSON/ Content	Total Frames	Text Frames	Text & Image	Question Frames	Motion Frames	Review Frames
	148	86	62	30	3710	3719
LIGHT	47	30	17	9	–	4
Wave Lenght Spectrum Color Electromagnetism						
STARS	59	32	27	12	–	5
Spectral Class Magnitude Color Temperature Brightness H-R Diagram						
STELLAR EVOLUTION	42	24	18	9	3710	3710
Protostar Helium Flash Planetary Nebula Evolutionary Track Red Giants, White Dwarfs						

The number of text frames and graphic overlay (text & image frames) equals the total number of frames. The number of question frames represents the number of practice questions embedded into each lesson. There was only one motion/sound sequence of frames and that was in the lesson on Stellar Evolution. The sequence lasted for approximately two minutes and summarized all three lessons. Its major focus, however, was on the evolution of stars and the methods of classifying them by their spectral classes. The review frames appeared at the end of each lesson and gave the student opportunity to call up additional review information or to practice with some additional questions.

A printout of selected frames from each lesson are provided in the appendix.

Instructional Treatments

Two computer-designed versions of the lessons and one printed, illustrated text were used in the study. These versions differed in the structure of the amount of learner control. The instructional treatments developed were: program control, student control, and experimental control.

Program Control. Students followed a linear path through the lesson. The student studied segments of the lesson, and answered a set of embedded questions in each of the lessons. The number of questions for each lesson were: Light - nine; Stars - twelve; Stellar Evolution - nine. After answering each of the questions, students were given knowledge of results and proceeded to the next segment of the lesson. No options were provided for controlling the sequence of the lesson, for tutorial review or for repeating a practice question. The student could control the amount of time spent on each frame and could branch backward to review a previous tutorial frame. This feature was also present in each of the other treatments.

Student Control. Students in this group controlled their path through the lesson. At various points in the lesson, the student was permitted to make an individual control decision on various options designed into the lessons. Those control decisions were as follows: Students were permitted to choose the order of the video segments through menu selection. At the point of the Lesson Menu the students were advised to review the Lesson Table of Contents in order to get an overview of the contents of the various lessons before choosing the lesson sequence.

Other options available to the students were a Glossary or a definition of terms, various help sequences, review segments, and lesson escape capabilities. As the student proceeded through the lesson, he/she could page backward to previous frames for review if they so desired. The student could not page backward for review while they were involved in a practice session with questions. The purpose and use of these options were explained in a short pre-lesson tutorial on computer keyboard operations, which was also optional to the student.

Students were given instructional control options after answering the embedded questions and given knowledge of results. If the answer was correct, the student proceeded to the next segment until the lesson was completed. If the answer was incorrect, the student was provided with the correct answer and the option of reviewing the segment before proceeding. After completing each lesson the student then branched to the Lesson Menu where he/she could select the next lesson option, review option, or test option.

Experimental Control. Students in this group served as the study control group and were given printed, black and white, illustrated text materials from Moche's self-teaching guide on "Astronomy." The students studied the same tutorial material, Light, Stars, and Stellar Evolution and identical practice test questions as were contained in the computer-assisted lessons used with the Program and Learner Control groups. The study guide contained practice questions, review sections, graphs and charts and an answer section to the questions.

Research Design and Data Analysis

The study was a quasi-experimental approach, Randomized Control-Group Pre-test, Post-test Design by Campbell & Stanley (1963). Students were randomly assigned to treatment groups, treatments were administered, and a post-test was given. The scores of each group's post-tests were compared to determine the impact of the treatments.

The study employed a 2(field dependent/field independent) by 3(Program Control, Student Control, Experimental Control) factorial design to determine the interactions between the dependent variables (learning styles) and the independent variables (the three treatment groups). The intent of the analysis was to determine if students with one type of learning style do better with a particular treatment group than students with another type of learning style (interaction); or if the degree of superiority of one learning style over the other is the same for all treatment groups (no interaction).

One-way Analysis of Variance (ANOVAs) procedures were used to analyse the pre-test scores for any significant differences among the three treatment groups to establish whether the students had relatively the same level of prior knowledge of the subject content before participating in the study. A two-way ANOVA was used to identify significant differences between the treatment groups (main effects) on the post-test , retention scores, and time-on-task data and any interactions with learning styles and the treatment groups. For any findings of significant difference between the treatment groups, a post-hoc procedure, Scheffe's test, was used to compare individual and group means.

<u>Random Assignment</u>

Each student volunteered to participate in the study by signing-up for time slots indicated on a time sheet. Assignment of the students to one of the three treatment groups was made in the following manner. The name of each student was written on a piece of paper and place in a box. The box was shaken several time very thoroughly in order to mix the slips of paper. Each name was withdrawn from the box, one at a time, and assigned to a treatment group, beginning with Treatment I, Program Control for the first name, Treatment II, Student Control for the second name, and Experiment Control for the third name. This process was continued until all 87 names had been assigned to one of the three treatment groups.

A list was made of the names for each treatment group, and each name was registered to an appropriated program via the student management component of the Quest software.

Procedures

Upon arrival to participate in the study, the student was asked to read and sign the Consent Form. The purpose of the study was explained to the student, but no details as to the difference in treatment groups was explained to the student. After logging onto the computer, some introductory material relating to the videodisc lesson was presented to the student. The student was then given the option of taking a short computer-assisted tutorial on micro-computer keyboarding and the use of relevant keys which were to be used during the course of the videodisc lesson.

Upon the completion of the keyboard lesson or upon the choice of not taking the keyboard tutorial, the student was then branched to the pre-test. After completion of the pre-test, the student's pre-test score was made known by the computer and the student was then branched to the main tutorial lessons on Astronomy.

In the case of the Experimental Control group, the student left the computer and was given a copy of the self-study guide and given an explanation on how to use and how to proceed through the lessons. The student was give one hour to complete the self-study guide. This time frame had been established from results of the field test with 60 students in which it was found that it took an average of 60 minutes to complete the computer-assisted lessons and a like amount of time to complete the review of the self- study guide.

After completing the computer-assisted tutorials or the self-study guide the student was branched to or signed on immediately to the post-test. Whenever the student completed the post-test, their test score was made known to the student and recorded to disc.

All treatments were administered individually in a room provided by the Physics and Astronomy Department. The room was used exclusively for the conduct of the study.

Formative Evaluation of Materials

After completing the original design of the computer-assisted treatments, field testing of the designs was conducted in order to discover any technical, mechanical, or logical flaws in any of the programs. Twenty subjects from the Physics and Astronomy Department were used with each of the three treatment groups. Upon completion of the exercise which consisted of a pretest, the tutorial, and a post-test, each student was asked to complete a survey form designed to measure their attitude towards videodisc instruction and suggestions as to what improvements were needed in the programs designs. Much useful data was collected which lead to improvements in the instructional design of the various lessons and in the design of the study itself. Attitudinal comments were enlightening as to student receptiveness to videodisc-style instruction. A copy of the survey document is included in the Appendix.

CHAPTER IV

DATA ANALYSIS AND RESULTS

Introduction

The results of the data analysis presented in this chapter are mixed, showing a significant difference for the main effects of the treatments for learner control, but no significant difference for the main effect of learning style. The analysis did show a disordinal interaction between learning style and the program treatment on the posttest, indicating that one type of student learned better with one method of the learner control treatment, while another type of student learned better with another method. However, the interactions are the reverse of what is predicted for each of the learning styles. A post-hoc analysis of these results attempts to explain this situation.

Results

Treatment Groups

The means and standard deviations of the three test scores, pretest, posttest, and retention test by the three treatment groups, Program Control, Student Control, and Experimental Control are presented in Table 4.

Test Means.

Table 4 Mean and Standard Deviations of Treatment Groups by Test Score

	Program Control		Student Control		Experimental Control	
	Mean	s.d	Mean	s.d.	Mean	s.d
Pretest	73	14.39	76	9.85	79	8.94
Postest	81	13.83	85	11.43	74	13.32
Retention	85	10.18	86	13.87	81	14.08

N = 29 for each treatment group
Total N = 87

In the two treatment groups, Program Control and Student Control, there was an increase in the mean test scores of the Posttest over the Pretest. This was not true for the Experimental Control Group. Of the three treatment groups, the highest mean test performance was in the Student Control group. Also there was an increase in the mean test score of the Retention test over the Posttest in all three treatment groups. This resulted from the fact that the students were learning in class between the time they took the posttest and the retention test.

The relatively high standard deviations in all treatment groups presented in Table 4 are due to the wide range of scores encountered on all three tests. For instance, the range of test scores on the pretest for the

Program Control group was a low of 22 to a high of 94. For the posttest scores with the same group, the range was a low of 46 to a high of 100.

Prior Knowledge.

In order to determine the equivalency of the Pre-Test scores for all treatment groups, an Analysis of Variance (ANOVA) was conducted to determine if there was any significant difference among the Pre-test scores. Table 5 summarizes those results, showing an F (2,84) = 1.67 < 3.11, indicating no differences at the .05 level of significance among the pre-test means of the three treatment groups. This indicates that all three groups began the study with approximately the same amount of prior knowledge relative to the subject of introductory astronomy.

Table 5 Group Differences in Mean Level of Pre-Test Achievement Among Groups

Source	df	MS	SS	F	Crit. F
Between Groups	2	444	222	1.67	3.11
Within Groups	84	11137	132		

Learning Styles.

Table 6 presents data on the means of the Post-Test scores by Learning Styles. These groups were identified from the resultsof the Concealed Figures Test. The total range of Normalized Standard Scores (NSS) falls between 0 and 100, with a mean of 50. The field-independent group consisted of subjects scoring 50 or better, and the field-dependent group of subjects scoring below 50. This method of classifying field dependency/independency has been used in studies by Courtier, Wattenmaker, & Ax (1965).

For the Program Control group, the field independent students did better on the Post-test than the field dependent students. For the Student Control group, field dependent students did better than field independent students. For the Experimental Control group, field independent students did better than the field dependent students. Of the three treatment groups, field dependent students in the Student Control treatment group performed better than any other students in any other treatment group. However, these results are opposite to what is predicted in the literature. It would be expected that the field dependent person would perform better in a learning situation where they have to make fewer choices regarding a learning strategy, as in the Program Control treatment. For the field independent person it is expected that they would perform best in a situation where they can take advantage of the options in making learning decisions, as in the Student Control treatment (Witkin & Goodenough, 1977).

Table 6 Means and Standard Deviations of Post-Test Scores by Learning Style

	Program Control		Student Control		Experiment. Control	
	Means	s.d.	Means	s.d.	Means	s.d.
Field Dependent	78	15.73	88	8.80	72	12.91
N =	19		16		14	
Field Independent	86	6.87	82	13.39	75	13.57
N =	10		13		15	

Total N = 87

Two-Way Analysis of Variance
Post-Test Scores

Table 7 summarizes the two-way analysis of variance of the post-test scores for main effects and for the interactions between learning style and the two treatment groups, Program Control and Learner Control.

Table 7 Summary of Main Effects and Two-Way Interactions Between Learning Styles and Treatment Groups For Post-Test Scores

Source	df	SS	MS	F	Crit.F
Main Effects					
Treatment Groups	2	1252.67	626.34	3.427	3.11
Learning Style	1	43.72	43.72	0.242	3.96
2-Way Interactions					
L.Style X Treatments	3	1946.34	648.78	3.594	3.11
Explained	6	1946.34	324.39	1.797	2.21
Residual	80	14439.93	180.50		
Total	86	16386.27			

Main Effects.

The ANOVA produced a main effect for treatments, F(2,80) = 3.4, p <.05, indicating a significant difference in the three treatment groups. A Scheffe's test, using the regression coefficients (b's) from the computer data showed no significant difference between the means of the Program Control group and the Student Control group (F=1.6 < 3.11, (df=2,83) at .05 level of significance. An additional analysis did reveal a significant difference between the means of the Program Control group and the Student Control group contrasted with the Experimental Control group F = 8.3 > 3.11,(df2,83) at the .05 level of significance.

Therefore, the first hypothesis that there would be a significant difference of the means test scores between the Program Control group and the Student Control group is not supported. However, the second hypothesis that there would be a significant difference of post-test scores of the Program Control and Student Control groups over the Experimental Control group is supported.

In order to determine the main effect of learning style beyond the effects of the three treatment groups, $F(1,80)=.242$, $p > .05$ showed no significant difference. Therefore, the third hypothesis that there would be a significant difference between the mean post-test scores of field dependent and field independent students in all treatment groups is not supported.

Interactions.

For the interactions between learning styles and treatment groups for learner control, the F-ratio between Learning Style and the three treatment groups is significant, $F(3,80) = 3.59$, $p < .05$. The hypothesis that there would be an interaction of learning styles with the treatments is supported.

Type of Interaction:

Figure 4 describes the interaction of Learning Styles and treatment. The type of interaction is disordinal since the vectors for the two variable intersect each other. For the Field Independent person, performance was best under Program Control treatment which had limited options for learning available. For the field dependent person, performance was best under the Student Control treatment where there were a variety of options, advisements, and opportunities for additional learning available for structuring a learning strategy. This, of couse, is opposite to the behavior that is predicted for the two learning styles.

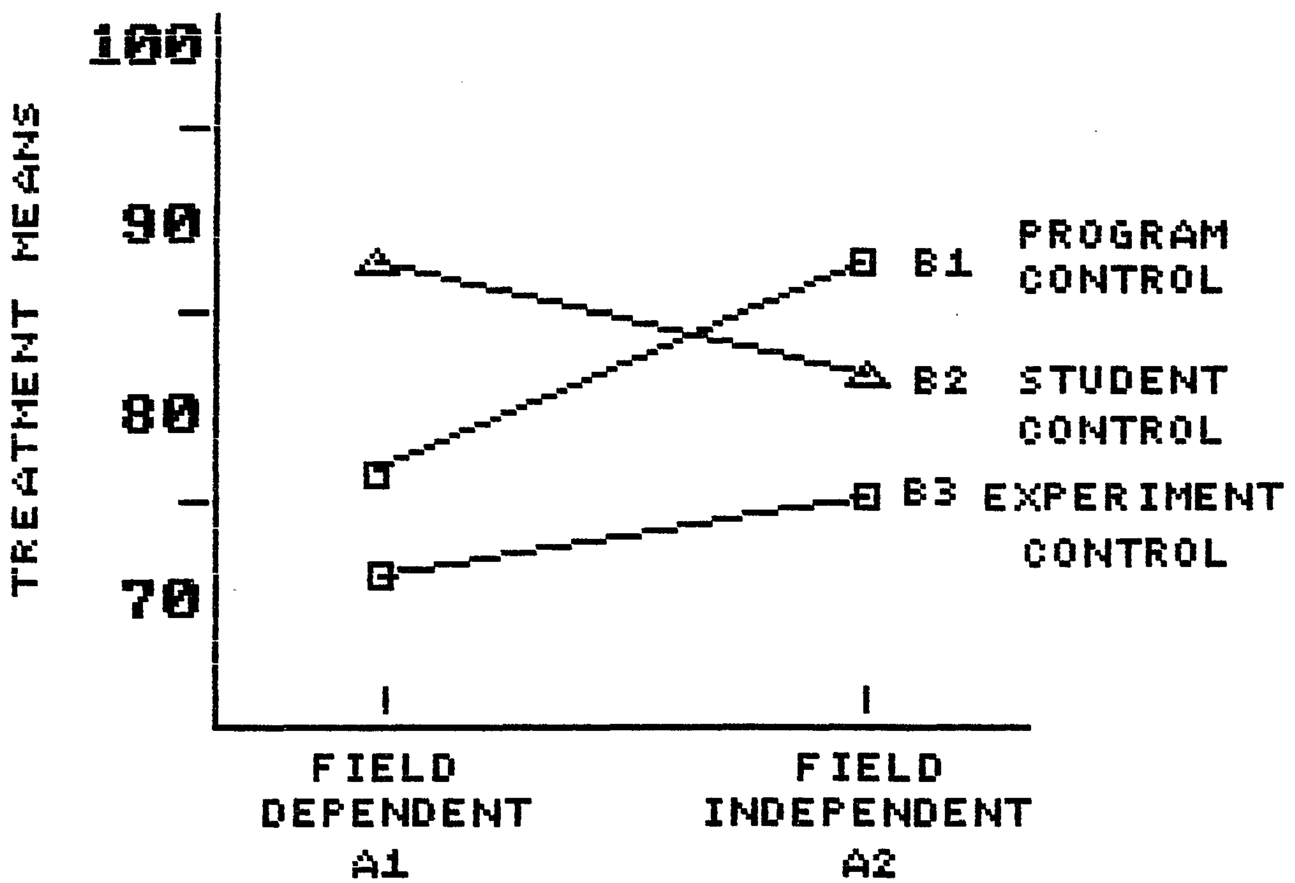

FIGURE 4. APTITUDE-TREATMENT INTERACTIONS POST-TEST SCORES

Two-Way Analysis of Variance
Retention-Test Scores

In order to determine if the effects of the Post-test scores carried over to the Retention-test scores a two-way Analysis of Variance was performed on the retention-test scores for main effects and for interactions between learning style and the two treatment groups, Program Control and Student Control. Table 8 summarizes the results of that analysis.

Table 8 Summary of Main Effects and Two-Way Interactions Between Learning Styles and Treatment Groups For Retention-Test Scores

Source	df	SS	MS	F	Crit.F
Main Effects					
Treatment Groups	2	320.34	160.17	0.917	3.11
Learning Style	1	0.45	0.45	0.003	3.96
2-Way Interactions					
L.Style X Treatments	3	182.55	60.85	0.348	3.11
Explained	6	325.59	54.27	0.310	2.21
Residual	78	13625.35	174.68		
Total	81	13950.94			

Main Effects.

The Anova produced no significant differences for the main effects for the treatment groups $F(2,78)=0.917$, $>.05$ on the retention scores. Also, there were no significant differences between learning styles with any of the treatments $F(1,78)=.003$, $>.05$.

Interactions.

For the interactions between learning styles and the treatment groups (learner control), there was no significant differences $F(3,78)=.348$, $>.05$.

Analysis of Time-on-Task

A post-hoc analysis was made to determine what may account for the findings in which the students with different learning styles performed differently than was predicted. The amount of time that each student spent on the tutorial and the Post-test was recorded as part of the student-management file. This data, time on-task, was used to see if students with different learning styles spent differnt amounts of time processing the information presented in the tutorial and the Post-test. Table 9 shows the means and standard deviations of the different treatment groups by learning style for time-on-task. The data shows that the field dependent students spent a longer amount of time with each of the three lessons than did the field independent students.

Table 9 Mean and Standard Deviations of Treatment Groups by Learning Styles for Time-on-Task

	Program Control		Student Control		Experimental Control	
	Means	s.d.	Means	s.d.	Means	s.d.
Field Dependent	55	5.73	59	8.80	63	10.67
N =	19		16		14	
Field Independ	48	6.87	53	9.39	57	8.69
N =	10		13		15	

Total N = 87 Time in minutes

Two-Way Analysis of Variance and Time-on-Task

In order to determine if there were any significant differences for the main effects and the interactions between learning styles and the treatment groups and learning styles and time-on-task, a two-way Analyis of Variance was done, using the Post-test scores and time on task recordings. The results are presented in Table 10.

Table 10 Summary of Main Effects and Two-Way Interactions Between Learning Styles and Treatment Groups For Post-Test Scores and Time-on-Task

Source	df	SS	MS	F	Crit.F
Main Effects					
Treatment Groups	2	1318.72	659.36	3.63	3.11
Learning Style	1	80.18	80.18	0.44	3.96
Time on Task	1	103.77	103.77	0.57	3.96
2-Way Interactions					
L.Style X Treatments	2	1458.16	729.08	4.02	3.11
L.Style X Time-on-Task	1	147.49	147.49	0.81	3.96
Explained	7	2050.11	292.87	1.61	2.21
Residual	79	14336.16	181.47		
Total	86	16386.28			

The results showed, for the main effects, a significant difference among the three treatment groups when accounting for time on task, $F(2,86) = 3.63$, $p < .05$. However, there was no significant difference by learning style or time on task. For the two-way interactions, there was a significant interaction between learning style and the treatment groups when accounting for time on task, $F(2,86) = 4.02$, $p < .05$. There was no significant difference for the interactions between learning style and time-on-task.

In order to determine the type of interaction, the mean recordings for time-on-task and the treatment groups were graphed and are presented in Figure 5.

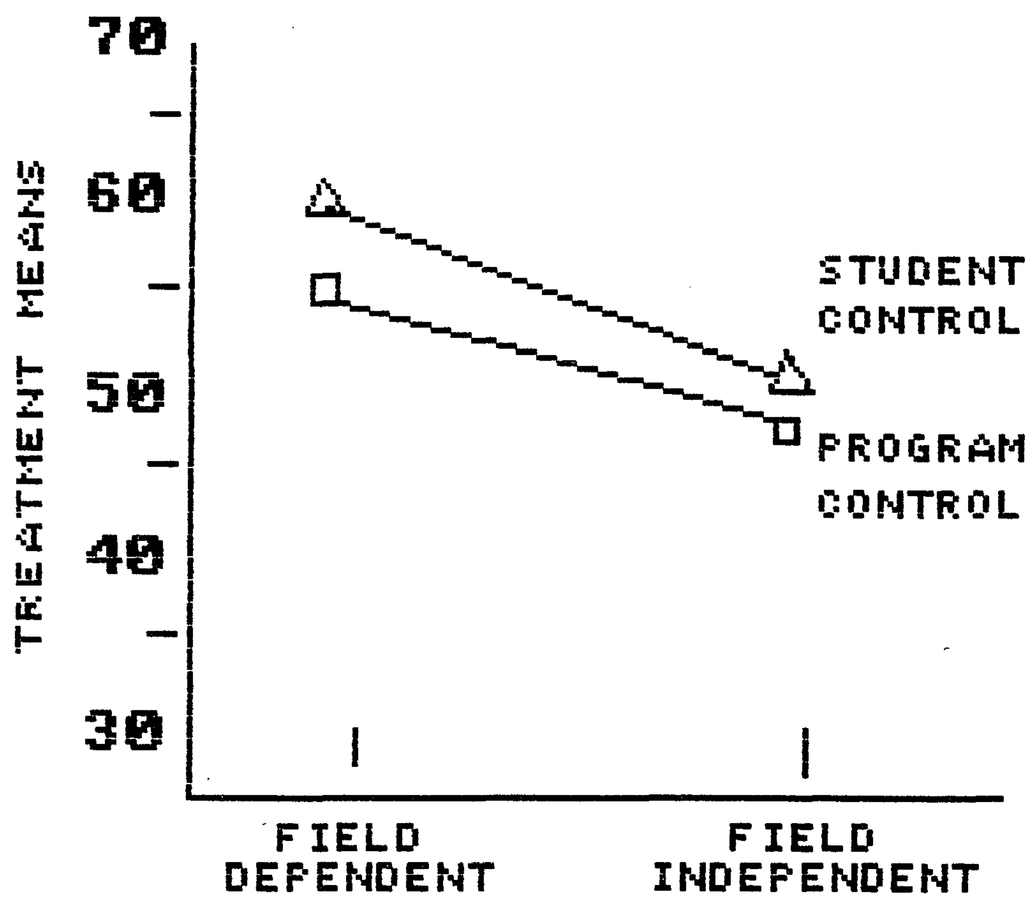

FIGURE 5. APTITUDE-TREATMENT INTERACTIONS
TIME ON TASK

Figure 5 describes the interaction between learning styles and the time-on-task recordings for the two treatment groups, Program Control and Student Control. The type of interaction is <u>ordinal</u>, since the vectors for the two treatments do not intersect each other, but are not parallel to each other. The data from Figure 5 confirms that the Field Dependent student did take longer on both treatment groups to process the information from the tutorial and from the Post-test and may account for the reason that they did better on the Student Control treatment than the Program Control treatment.

Summary

The results from the analysis of the Post-test scores showed a significant difference for the main effects of the treatment groups, indicating that the type of learner control method did affect learner performance. However, the difference was between the two treatments of Program Control and Student Control groups contrasted with the Experimental Control group.

An analysis of the Retention-test scores showed a diminishing effect for recall of information between the time of the Post-test and the Retention test. A possible explanation for this may have to do with the fact that participation in the study had little effect upon the final grade of the student, resulting in lower motivation for learning. Also, the majority of the type of questions used in the study were of the short-term recall category, which easily be forgotten upon completion of the learning exercise.

A disordinal interaction was found to exist between learning styles and the treatment groups with learning styles and treatment groups interesecting each other and showing performance best for field dependent learners in the Student Control group, while, for the field independent learner, Program Control treatment was the best. This is the reverse of what was predicted in the literature in that field dependent students are seen as those type of students preferring to let the system make learner choices for them, while the field independent students prefer to make theiro wn choices for learning, and aggressively seek out options to do so. A possible explanation for this may have to do with the findings from analysis of the time-on-task recordings that the field dependent student spent more time on each of the three lessons trying to process the information. This would have been true with the Student Control lesson, where there were more options and information to consider than with the Program Control lesson. Another factor may have to do with issue that the field independent students did not exericse all their options for learning. This is one conclusion from the literature explaining that students do not make the right choices or exercise all their options under learner control conditions.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

The purpose of this study was to examine the interaction of different learning styles with different instructional presentations involving learner control using an interactive videodisc system. Specifically, the issue was to determine if field-independent and field-dependent learners performed differently from each other under different instructional treatments where the amount of learner control varied through the environment of interactive videodisc learning. The questions investigated were: Will field-independent learners perform better than field dependent-learners in an unstructured learning environment, which allows the the learner to fashion his own strategies to the task? Will the field-dependent learner perform better than the field-independent learner in a structured learning environment that contains guidance, cues to learning, and access to additional little learning support?

Learning styles were measured by the Concealed Figures Test, which identified the learner as being either field dependent or field independent. Participants were randomly assigned to one of three treatment groups, Program Control, Student Control, and Experimental Control. The Program

Control treatment was a linear-designed program, giving the learner limited choices in the pace, path, and/or amount of instruct ional exposure. The Student Control treatment was a multi- level program, which allowed the learner choices as to pace, path, and amount of instructional exposure. The Experimental Control treatment was a written text consisting of a self-study guide which the student reviewed for a specified time period.

Pretests were administered to determine the amount of prior knowledge of the subject matter, introductory astronomy. Posttests measured the amount of learning achievement gained from the instructional treatment, and a Retention test measured the amount of learning retained one week after exposure to the instructional treatment.

The results of this study indicated improvement in learning achievement when using the interactive videodisc tutorial. While there was no significant difference of post-test performances between those students assigned to the Student Control group and the Learner Control group, there was a significant difference between the two groups when compared with the Experimental Control group.

There were differences of performance between the field dependents and field independents assigned the three treatment groups. However, there were no significant differences of learning between these groups with any of the instructional methods. Finally, there was an interaction of learning styles, with the treatment groups for learning control, indicating that for the field dependent student, the Learner Control method was the better, while for the field independent student the Program Control method was the best. These results are opposite to what is predicted in the literature in terms of behavior for the two learning styles, field dependency and field independency. These findings are discussed further under the Hypotheses section of this chapter.

The data from Table 8, Chapter IV showed that the effects of the Post-test scores diminished significantly when measured by the Retention-test scores. That is, very little of the information from the tutorial was retained during the week that elapsed between the tutorial and posttest and the retention test. Several plausible reasons may be suggested as to why this effect resulted. The most important reason may be the lack of motivation for retaining the information, since the student's participation in the study did not measurably affect their classroom grade. Although participation in the study did result in extra grade credit, there was no test score from the study that had any bearing on the student's final grade. Another reason for lack of effect regarding the Retention-test scores may have to do with the level of information processing required from the type of questions in the pre-test, post-test and the retention-test. As revealed in

Tables 2 and 3 of Chapter III, most of the questions were simple recall of information presented in the tutorials. Therefore, the information processing was not deep enough to positively affect retention.

The remainder of this chapter consists of discussion of the findings in support of the aptitude-treatment interaction hypothesis, the implications of the study, the limitations of the study, and recommendations and conclusions drawn from the findings of the study.

Hypotheses

Hypothesis I: There was be a significant difference between the mean post-test scores of students assigned to the Student Control treatment group over students assigned to the Program Control treatment group.

The data from the test means, Table 1 showed the students in the Student Control treatment group outperformed students from either the Program control or the Experimental Control groups. The data from the ANOVA, Table 4. showed there to be a significant difference of the post-test scores among the three treatment groups, $F = 3.42 > 3.11(df, 2,79)$, indicating that the type of learner control method did affect learning performance. However, a post-hoc comparison of the treatment means by Scheffe's method showed no significant difference between the instructional groups, Program Control and Learner Control.

Therefore, the first hypothesis of significant differences between the two groups, Program Control and Learner Control is not supported.

Hypothesis II: There was be a significant difference between the mean post-test scores of those students assigned to the Program Control group and the Learner Control group compared with those students assigned to the Experimental Control group.

The data from Table 1 showed that students in both the Program Control and the Learner Control group haqd higher post-test scores than those students assigned to the Experimental Control group. Data from Table 4 showed there to be a significant difference of the post-test scores among the three treatment groups. A post-hoc comparison of the test means by Scheffe's method revealed a significant difference of the post-test means of the two instructional groups, Program Control and Learner Control over the Experimental Control group. This indicates effectiveness of videodisc instruction over the non-videodisc instruction used in this study.

Therefore, the second hypothesis that the post-test scores of the Program Control group and the Learner Control group would differ significantly from the Experimental Control groups is supported.

<u>Hypothesis III</u>: There was be a significant difference of post-test scores between field dependent and field independent students in all treatment groups.

The data from Table 3 showed a difference of post-test scores between the field-dependent and field-independent students in all three treatment groups. However, the results from Table 4 showed no significant difference of performance between the two learning styles with the treatment groups, $F = .242 < 3.96$, meaning that the two groups of students did not perform significantly different on any of the methods for learner control. Therefore, the third hypothesis is unsupported.

<u>HYPOTHESIS IV</u>: There was be an interaction between learning styles and the two treatment groups, Program Control and Student Control.

The data from Table 4 showed a significant interaction between the learning styles, field dependent/field independent and the program treatments for learner control. The interaction between learning style and treatment groups was disordinal, showing that for the field dependent learner, the Student Control method was superior over the Program Control method, while for the field independent learner, the Program Control method was superior.

These results are also demonstrated in Table 3. where the two types of learners performed differently with the three treatment groups of learner control.

These findings are reverse to research conclusions that field dependent learners would function better in a forced learning environment, where there are limited options for devising alternate learning strategies. For the field independent learner, the research conclusions are that field independents would function better in a learning environment where they can impose their own structure, and make choices from among a number of options as to a learning strategy (Witkin, et al. (1962, 1974); McLeod et al. (1978).

Data was presented in Chapter IV which suggested that the time-on-task variable had some influence upon the performance of the two learning groups. It was found from the data that field dependent students spent more time on all the lessons trying to process the information than did the field independent students. This may account for the reason why the field dependent students did better in the Student Control group than they did in the Program Control group. They were more sensitive to the highlighting cues, studied the options longer and consequently took longer to process the information.

Another explanation for these findings may be that the students, regardless of learning style, did not exploit fully the options that were available to them for addition learning that were part of the Student Control lesson. A reveiw of the Student Management files, showed that most of the students proceeded in a linear fashion through all the lessons, rather than in a random fashion where the opportunity was available.

Therefore, the fourth hypothesis is supported in that a significant interaction was found between learning styles and the treatment groups for learner control. However, qualifications for this finding must be noted as explained in the above discussion.

Implications of the Study

Implications for Instructional Design

The information provided from the results of this study has implications for the instructional designer in that it reinforces the notion that computer-assisted instruction is a viable means for individualizing instruction when taking into account the many characteristics of the learner. The study demonstrates that all learners do not approach the learning situation in the same manner and that their perception of visual information is processed in a variety of different ways. Several factors can distract the learner in attempting to perceive a visual display and comprehend its meaning. Such factors include poor quality of computer-generated graphics, crowded visual displays, overuse of textual cueing. These factors can influence the manner in which learners are able to perceive and interpret visual information. While field independents are in a better position to ignore visual distractions, the field-dependent learner has difficulty in extracting visual information from a confusing background field. Therefore, the instructional designer must pay careful attention to the quality of the visual display generated by the computer or by the videodisc.

Finally, the study supported the recommendations of researchers (Tennyson, 1980,1981; Tennyson & Buttrey, 1980, Ross, 1984) on the issue of learner control and the use of advisement strategies as support in learning. The study shows however, that for some learners, such advisement strategies are unnecessary. The field independent learner would tend to ignore such recommendations and impose his own structure upon the situation. Therefore, a mismatch between learning strategy and learning style could hinder the learning process.

When developing computer-assisted courseware, the tendency is to develop a single-template design that can be applied to the broadest range of users, regardless of their individual characteristics. The high cost in time and effort to develop multiple-templates for multiple considerations is almost prohibitive. Jonassen's (1982) recommendation of developing instructional products with a broad range of "content" which can accommodate to several diagnosed-learner characteristics seems appropriate at this point. Instructional designers developing computer-assisted courseware must be mindful of the many learner characteristics that interact with different instructional approaches. One instructional approach will not necessarily fit all learners in an appropriate way, and can lead to a mismatch between learner and instruction. What is needed is instructional content with multiple control options as means of accessing to the different levels of content, based upon some pre-diagnosis of learner characteristics and needs.

Implications for Research

The information provided from the results of this study has implications for instruction designers of computer-assisted courseware. In designing software there is a need to work just as much from the communication point of view as from the educational (Hammond, 1985). Communication, whether from a text, television, or a computer depends upon a balance between the sender and the receiver through a matching of encoding and decoding of signals, symbols, and meanings. Computer courseware is developed with purposes in mind to lead to some gain in knowledge and skills and some motivation to change attitudes in certain aspects of the learner. The success with which software is able to accomplish these goals depends very much on the care with which it has been developed against the current ideas and theory about the relationship of visual literacy and cognitive style and the findings of research on the effectiveness of micro-computer as a teaching medium. It has been pointed out by Salomon (1974) that:

> "symbolically different presentations of information vary as to the mental skills of processing that they require ...media's ways of structuring and presenting material, i.e. their symbol system are media's most important attributes when learning and cognitions are considered" (p. 216)

The interactive videodisc learning environment, with it's rich visual/auditory forms of presentation and its cueing through the use of color, highlighted text, motion, bordering, underlining, serves to focus the learner's attention on material to be learned. Interactive videodisc systems also offer a unique opportunity to further study the interactions between different learning styles and visual media. With interactive video systems, aspects of the visual presentation can be easier controlled or modified at the design stage than is the case with any other medium such as written text, videotape, or television. Therefore, a mix and match between learning style and visual presentation can be investigated in a variety of ways that are easy to design and economically efficient to produce.

In assessing the relationship of cognitive style and the role of the interactive videodisc in learning, future research will need to examine:

a) how cognitive styles affect the ways in which a learner perceives and organizes the visual presentation.

b) how visual material can be used to overcome the disadvantages some students may suffer because of strategy mismatch, as in the case of learner control.

c) how much distraction in the visual field the learner can tolerate as the result of overuse and overabuse of various cueing systems, such as color, motion, typographical manipulations.

d) how to develop materials that will test higher levels of information processing than simple factual recall. Designers must break away from the true/false, yes/no format of testing that is so bound up with microcomputer structures.

Microcomputers and interactive videodisc systems now employ a variety of response input devices, in addition to the keyboard, such as mouses, joysticks, and touch-sensitive screens. The opportunity to investigate the interactions of haptic learners with the micro-computer and with visual material is now available as never before. There is a unique opportunity to devise tasks that will involve the haptic-type learner interactively in micro-computer instruction. For instance, require the learner to use a mouse devise as a drawing tool for purposes of reproducing pictures, which represent concepts that have been taught by the computer. As a medium, the computer is no longer limited to a viewing-thinking format. It now involves the learner in a doing-format as well.

Limitations of the Study

Certain limitations within this study could affect the generalization of results.

Treatment Population

The subjects in this study were all college students and the majority were registered in an Introductory Astronomy Course at the time of this study. While most of students completed their participation in the study before the mid-term exam in the astronomy course, they were being stimulated with data and facts from the course which may have contributed to their ability to obtain high test scores on the pre-test, post-test, and the retention test.

Replications of this study are needed with subjects who are not involved in astronomy either as a student or a practioneer and who are less aware of the data and facts associated with introductory astronomy at the beginning of a study.

Test Instruments

The retention test was a paper and pencil test and therefore, could not be compared with a computer-administered test of the same nature as to effectiveness. The reason the recall test was in paper-and-pencil form is because there was only one videodisc workstation available for the study and it was in constant use over a period of three months by those students taking the original tutorials. The retention test was administered one week after the student completed the original tutorial. Therefore, there was an overlap in scheduling of students taking the tutorial and those taking the recall test. It might be assumed that the a student would visually process the same information differently between a computer- administered test and a paper and pencil test.

If this is true, then the results of the retention test might be reevaluated. This could form the basis of an investigation to determine if there is a difference in performance between text-based information processing and computer-based information processing. Brittain, Dunkel, & Coull (1979) suggest that field independent persons are more active scanners of visual material than field dependent persons. Therefore, field independent persons score higher for instruction that is in either audio or written form, but field dependent learners consistently score higher from television presentations (Danielson, Seiler, & Friedrich, 1979).

The principle test instrument used in this study to classify students as to their learning styles was the Concealed Figures Test (CFT) by Thurston and Jefferies (1965). The relevance of this test instrument to the study of field dependence/independence has already been cited. However, many researchers have used a Group Hidden Figures Test (GHFT) (Ekstrom, et al., 1976) to study the same learning styles. In some studies researchers have used both tests to measure field dependence/independence and have occasionally found different amounts of variation in performance attributable to the two tests (Daugherty & Waters, 1969; Wormack, 1976) Future research with interactive videodisc systems and the interactions of learning styles with visual/cognitive tasks might utilize both test forms (CFT, GHFT) to study field dependence/ independence.

Conclusions

In this study the interactions between learning styles (field dependence/independence) and learner control in an interactive videodisc lesson on astronomy were examined. A strong interaction was found between the two variables and a significant difference was found between the two learning styles. Additionally, a significant difference was found between the two treatment groups of Program Control and

Student Control. The interaction was greatest for field dependence and learner control, which is contrary to the hypothesis that field dependent learners will not utilize the many visual and strategy support systems of a learning situation to their advantage.

There is a need for additional study into the effects of visual and cognitive tasks upon learning within an interactive videodisc environment.

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APPENDIX A

CONSENT FORM

CONSENT FORM

FOR PARTICIPATION IN RESEARCH PROJECT

"INTERACTION OF LEARNING STYLES WITH LEARNER CONTROL TREATMENTS IN AN INTERACTIVE VIDEODISC LESSON ON ASTRONOMY"

I AGREE TO PARTICIPATE IN THE PRESENT STUDY BEING CONDUCTED UNDER THE SUPERVISION OF **DR. STEVE DANFORD**, A FACULTY MEMBER OF THE UNIVERSITY OF NORTH CAROLINA GREENSBORO, AT THE DEPT OF PHYSICS AND ASTRONOMY , AND **LAWRENCE B. BURWELL**, PRINCIPAL INVESTIGATOR, DOCTORAL STUDENT WITH THE SCHOOL OF EDUCATION, UNIVERSITY OF NORTH CAROLINA, GREENSBORO. I HAVE BEEN INFORMED, EITHER ORALLY AND/OR IN WRITING ABOUT THE PROCEDURES TO BE FOLLOWED. I UNDERSTAND THERE ARE NO DISCOMFORTS OR RISKS INVOLVED IN MY PARTICIPATION. THE INVESTIGATOR HAS OFFERED TO ANSWER FURTHER QUESTIONS THAT I MAY HAVE REGARDING THE PROCEDURES OF THIS STUDY. I UNDERSTAND THAT I AM FREE TO TERMINATE MY PARTICIPATION AT ANY TIME WITHOUT PENALTY OR PREJUDICE.

I ALSO GIVE PERMISSION TO THE PRINCIPLE INVESTIGATOR TO HAVE ACCESS TO MY COLLEGE FILES FOR PURPOSES OF OBTRAINING A RECORD OF MY **SAT SCORES**, WHICH I UNDERSTAND IS INFORMATION THAT WILL BE USED IN THE DATA ANALYSIS OF THIS RESEARCH PROJECT.

I UNDERSTAND THAT ALL DATA IN THIS PROJECT IS TO BE KEPT CONFIDENTIAL, AND THAT ONLY GROUP DATA IS TO BE REPORTED IN THE FINAL DOCUMENT RESULTING FROM THIS PROJECT.

__________ __________ _______ ________________
DAY MONTH YEAR SIGNATURE

ADDITIONAL DATA: STATUS IN SCHOOL:

FRSMAN___, SOPH____, JUNIOR____, SENIOR_____,
GRAD_____, SPEC___

MAJOR FIELD OF STUDY:______________________________

PREVIOUS COURSEWORK IN ASTRONOMY: YES______ NO______

SOCIAL SECURITY NUMBER: ______________________

APPENDIX B

EVALUATION FORM

EVALUATION OF COMPUTER COURSEWARE

Dear Student

Thank you for your participation in the evaluation of this computer program. Now that you have completed the program, I would like to have your documented comments on what you think of the system. To that extent, I would like to ask you to complete this brief survey of your opinions, judgements, and critique of the program. These will help me determine where changes need to be made before the program is used in its final form.

The attached form is designed in such a way as to allow you to agree or disagree with each statement. For those statements with which you disagree, please provide a brief comment as to where or why you had problems. I not only want to know that you had problems, but I want to get some idea of where the problems were. Space is provided for you to note your comments.

Thank you for your help in this project.

COURSEWARE EVALUATION

A=AGREE
D=DISAGREE
NO=NO OPINION

CIRCLE 1,2,OR, 3 FOR YOUR RESPONSE

DESIGN	A	NO	D
1. The learning objectives for each lesson were clearly stated.	1	2	3
2. I felt I had achieved the learning objectives after finishing the lesson.	1	2	3
3. The program challenged me intellectually	1	2	3
4. I was confused by the use of different colors for the various graphics and text.	1	2	3
5. The amount of information presented was overwhelming to my ability to understand it all.	1	2	3
6. I felt I had control over the sequence of presentation and amount of review.	1	2	3

CONTENT			
1. The amount of time to complete the program was appropriate for me.	1	2	3
2. I was able to complete the program without feeling tired or exhausted.	1	2	3
3. The content of the program, in general, maintained my interest effectively.	1	2	3
4. Explanations of concepts were confusing.	1	2	3
5. I felt there were enough practice questions within each of the lessons.	1	2	3
6. I was provided the opportunity to review each lesson before proceeding to the next lesson.	1	2	3

A=AGREE
D=DISAGREE
NO=NO OPINION

CIRCLE 1,2,OR, 3 FOR YOUR RESPONSE

TESTING:	A	NO	D
1. The test items were clear and without ambiguity.	1	2	3
2. Testing was monotonous and boring.	1	2	3
3. The program informed me of any incorrect responses to test items.	1	2	3
4. Test items were related to concepts and the text that I had previously studied.	1	2	3
VIDEO/AUDIO:			
1. Color quality was excellent and enhanced learning.	1	2	3
2. I was frequently confused with the way information was arranged on the screen.	1	2	3
3. Text was clear and easy to read.	1	2	3
4. Special effects was effectively used to enhance my learning.	1	2	3
5. Sound/narration was effectively used.	1	2	3
SYSTEM USE:			
1. I was able to use the computer equipment (keyboard) without any difficulty.	1	2	3
2. The equipment was arranged so as to enhance my comfort while engaged in the program.	1	2	3

Comments: Please write your comments in the section below:

DESIGN:

CONTENT:

TESTING:

VIDEO/AUDIO:

SYSTEM USE:

APPENDIX C

SELECTED PRE-TEST QUESTIONS

Frame TWELVE

Erase - Yes; Backup - NO

Which source is not used to observe stars in the night sky?

[1] Telescope

[2] Binoculars

[3] Microscope

[4] Naked eye

Type 1,2,3 or 4 _____ and Press Enter

Perf/Branch

Correct answer, weight = 5
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 156 y = 152
3
Rectangle 210 76 319 136
Text: x =218 y = 88
Correct,
they are not
used for
looking at
stars.
Branch type - UBR, dest frame is THIRTEEN

Unexpected answer, weight = 0
Text: x =218 y = 88
No, they
are used
to look
at stars.
Branch type - UBR, dest frame is THIRTEEN

Frame FORTY-ONEA

Erase - Yes; Backup - NO

The normal chemical reaction inside the core of a star is:

[A] The binding of oxygen to hydrogen;

[B] The conversion of hydrogen into helium;

[C] The fusion of iron into lead.

Type A,B,or C:______ Press Enter.

Perf/Branch

Correct answer, weight = 5
Character answer analysis
Ord - Y Subset - N Extra - N Tol - N
Input mode - Norm
Answer field 1: x = 150 y = 150
B
Text: x =106 y =168
Correct
Branch type - UBR, dest frame is FORTY-TWO

Unexpected answer, weight = 0
Text: x =106 y =176
No, it's B
Branch type - UBR, dest frame is FORTY-TWO

Frame SEVENTEEN

Erase - Yes; Backup - NO

The diagram you just saw is that of a family of electromagnetic waves which penetrate the earth's atmosphere and provides astronomers [redacted] through which to study properties of the stars. If you were viewing the stars through a telescope on earth, through [redacted] would you look? Go to the next frame and make your choice.

Perf/Branch

Branch type - UBR, dest frame is EIGHTEEN

Frame TWENTY-SIX

Erase - Yes; Backup - NO

Characteristics of a star such
as its chemical composition:

[1] Can be measured and stated in specific terms;

[2] Can only be guess at, since there are no instruments to take such measures;

[3] Cannot be measured, since stars are too far away;

[4] None of the above.

Type 1,2,3 or 4 ______ and Press Enter

Perf/Branch

Correct answer, weight = 5
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 150 y = 168
1
Text: x =122 y =184
Yes
Branch type - UBR, dest frame is TWENTY-SEVEN

Unexpected answer, weight = 0
Text: x =122 y =184
No
Branch type - UBR, dest frame is TWENTY-SEVEN

Frame THIRTY-SIX

Erase - Yes; Backup - NO

Our Sun is considered to be ..

[1] A planet;

[2] A star;

[3] A comet;

[4] None of the above.

Type 1,2,3 or 4 _____ and Press Enter

Perf/Branch

Correct answer, weight = 5
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 152 y = 146
2
Text: x = 98 y =168
Yes, look at the next frame
Branch type - UBR, dest frame is THIRTY-SEVEN

Unexpected answer, weight = 0
Text: x = 98 y =168
No, look at the next frame
Branch type - UBR, dest frame is THIRTY-SEVEN

Frame FORTY

Erase - Yes; Backup - NO

The general evolutionary cycle of a star is ....

[1] Birth, gradual expansion, and death;

[2] Birth, steady state of eternal existence;

[3] Continuous state of existence since beginning of time;

[4] Stars do not have an evolutionary cycle.

Type 1,2,3 or 4 ________ and Press Enter.

Perf/Branch

Correct answer, weight = 5
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 160 y = 160
1
Text: x =154 y =177
Yes
Branch type - UBR, dest frame is FORTY-ONE

Unexpected answer, weight = 0
Text: x =154 y =185
No
Branch type - UBR, dest frame is FORTY-ONE

Frame FORTY-TWO

Erase - Yes; Backup - NO

In the Milky Way Galaxy where
is our Sun located?

1 In the center;

2 On one of the spiral arms;

3 In the halo;

4 None of the above.

Type 1,2,3 or 4 ______ and Press Enter.

Perf/Branch

Correct answer, weight = 5
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 150 y = 152
2
Text: x =122 y =168
Yes, look at the next
frame.
Branch type - UBR, dest frame is FORTY-THREE

Unexpected answer, weight = 0
Text: x =122 y =168
No, look at the next
frame.
Branch type - UBR, dest frame is FORTY-THREE

APPENDIX D

SELECTED POST-TEST QUESTIONS

Frame TWENTY

Erase - Yes; Backup - NO

LABEL THE SPACES THAT CORRESPOND
TO THE EVOLUTIONARY PATH OF A STAR.

TYPE 1,2,3,OR4 IN SPACES
USE ARROW KEYS. PRESS
ENTER

3

2

1

RED GIANT ——
RED DWARF ——
MAIN SEQUENCE STAR ——
PLANETARY NEBULA ——

4

Perf/Branch

Correct answer, weight = 8
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 118 y = 120
Answer field 2: x = 116 y = 132
Answer field 3: x = 186 y = 140
Answer field 4: x = 176 y = 152
2 4 1 3
Text: x = 74 y = 96
Y
Text: x = 74 y = 96
YES
Branch type - UBR, dest frame is TWENTY-ONE

Unexpected answer, weight = 0
Text: x = 58 y =110
NO,IT'S
Text: x =134 y =120
2
Text: x =134 y =130
4
Text: x =196 y =140
1
Text: x =186 y =152
3
Branch type - UBR, dest frame is TWENTY-ONE

Frame NINETEEN

Erase - Yes; Backup - NO

Match the following definitions.

1. WHITE DWARF	___	Star that changes periodically in size & brightness
2. HELIUM FLASH		
3. PLANETARY NEBULA	___	Star that has blown its hydrogen shell
4. VARIABLE STAR		
Type 1,2,3,or 4 on spaces. Use Arrow Keys. Press Enter.	___	Star,below the Main Sequence in the H-R diagram, which is small & dense.

Perf/Branch

Correct answer, weight = 6
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 160 y = 50
Answer field 2: x = 158 y = 94
Answer field 3: x = 158 y = 142
4 3 1
Text: x =146 y = 64
yes
Text: x =154 y =112
yes
Text: x =146 y =160
yes
Branch type - UBR, dest frame is TWENTY

Unexpected answer, weight = 0
Text: x =138 y =178
NO,IT'S
Text: x =146 y = 50
4
Text: x =154 y = 82
4
Text: x =146 y =146
1
Branch type - UBR, dest frame is TWENTY

Frame EIGHTEEN

Erase - Yes; Backup - NO

MATCH THE FOLLOWING DEFINITIONS:

1. MASS

2. HYDROGEN INTO HELIUM

3. PROTOSTAR

4. ORION NEBULA

TYPE 1,2,3,OR 4 IN SPACES. USE ARROW KEYS. PRESS ENTER.

____ REGION OF SKY WHERE STARS ARE BEING BORN.

____ FACTOR THAT DETERMINES STAR'S LOCATION ON MAIN SEQUENCE

____ NUCLEAR REACTION IN CENTER OF STAR.

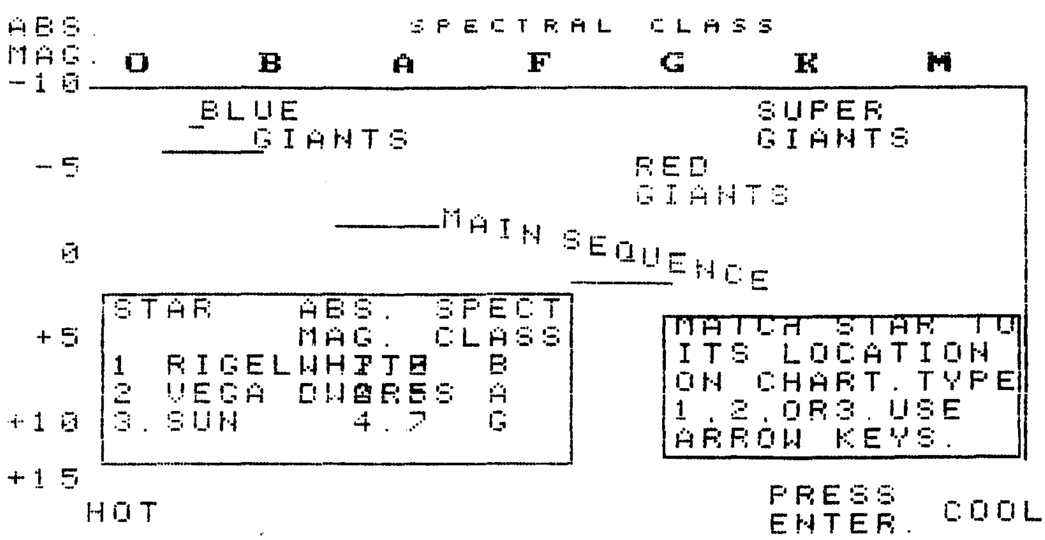
Perf/Branch

Correct answer, weight = 6
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 168 y = 54
Answer field 2: x = 168 y = 99
Answer field 3: x = 168 y = 146
4 1 2
Text: x =130 y = 96
YES
Branch type - UBR, dest frame is NINETEEN

Unexpected answer, weight = 0
Text: x =116 y =104
NO,
IT'S
Text: x =156 y = 56
4
Text: x =156 y = 99
1
Text: x =156 y =145
2
Branch type - UBR, dest frame is NINETEEN

Frame FOURTEEN

Erase - Yes; Backup - NO



Perf/Branch

Correct answer, weight = 5
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 52 y = 50
Answer field 2: x = 106 y = 72
Answer field 3: x = 168 y = 94
1 2 3
Text: x = 42 y = 72
YES
Branch type - UBR, dest frame is FIFTEEN

Unexpected answer, weight = 0
Text: x = 42 y = 90
NO,IT'S
Text: x = 42 y = 50
1
Text: x = 98 y = 66
2
Text: x =158 y = 98
3
Branch type - UBR, dest frame is FIFTEEN

Frame THIRTEEN

Erase - Yes; Backup - NO

FOUR NEARBY STARS

STAR	APPARENT MAGNITUDE	ABSOLUTE MAGNITUDE	SPECTRAL CLASS
1. RIGEL	0.1	-7.0	B
2. SIRIUS	-1.5	1.4	A
3. BARNARD'S STAR	9.5	13.3	M
4. CANOPUS	-0.7	-4.7	F

MATCH THE FOLLOWING FOR EACH STAR.
TYPE 1,2,3,OR 4

A. HOTTEST:____ C. FAINTEST APPEARING:____
B. COOLEST:____ D. REALLY BRIGHTEST:____
USE THE ←→ ARROW KEYS TO MOVE CURSOR
& PRESS ENTER.

Perf/Branch

Correct answer, weight = 7
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 100 y = 154
Answer field 2: x = 98 y = 166
Answer field 3: x = 302 y = 154
Answer field 4: x = 292 y = 166
1 3 3 1
Text: x =274 y = 88
YES
Branch type - UBR, dest frame is FOURTEEN

Unexpected answer, weight = 0
Text: x =274 y = 80
NO,
IT'S
Text: x =114 y =156
1
Text: x =114 y =168
3
Text: x =312 y =154
3
Text: x =303 y =165
1
Branch type - UBR, dest frame is FOURTEEN

Frame ELEVEN

Erase - Yes; Backup - NO

MAGNITUDE CHART

STAR	APPARENT MAGNITUDE
Sirius	-1.5
Rigel	0.1
Aldebaran	0.8
Antares	1.0
Pollux	1.2
Bellatrix	1.6

Is [illegible] brighter than Antares?
Type Y or N _____ Press Enter.

Perf/Branch

Correct answer, weight = 5
Character answer analysis
Ord - Y Subset - N Extra - N Tol - N
Input mode - Norm
Answer field 1: x = 140 y = 170
Y
Text: x =138 y =184
Yes
Branch type - UBR, dest frame is TWELVE

Incorrect answer, weight = 0
Character answer analysis
Ord - Y Subset - N Extra - N Tol - N
Input mode - Norm
Answer field 1: x = 140 y = 170
N
Text: x =186 y =104
NO
Text: x =218 y = 82
BRIGHT
Line at 240 83 1 segments
Text: x =218 y =127
FAINT
Branch type - UBR, dest frame is TWELVE

Frame TEN

Erase - Yes; Backup - NO

SPECTRAL CLASSIFICATION

O B A F G K M

____ ____

WHAT IS THE COLOR OF THE
UNDERLINED STAR TYPE.

TYPE RED OR BLUE IN THE SPACES FOR
EACH STAR TYPE (O, M).

USE THE ARROW
KEYS, PRESS
ENTER.

Perf/Branch

Correct answer, weight = 5
Word answer analysis
Ord - Y Subset - N Extra - N Tol - N
Input mode - Norm
Answer field 1: x = 40 y = 74
Answer field 2: x = 216 y = 74
BLUE RED
Text: x = 42 y = 88
YES
Text: x =218 y = 88
YES
Branch type - UBR, dest frame is ELEVEN

Unexpected answer, weight = 0
Text: x =122 y = 72
NO,IT'S
Text: x =218 y = 88
RED
Text: x = 34 y = 88
BLUE
Branch type - UBR, dest frame is ELEVEN

Frame NINE

Erase - Yes; Backup - NO

SPECTRAL CLASSIFICATION

O B A F G K M

WHICH STAR TYPES HOULD HAVE THE
FOLLOWING TEMPERATURES(K).

____ >30,000

____ 2,000-3,500

TYPE THE LETTER OF THE STAR TYPE IN THE SPACE. PRESS ENTER.

Perf/Branch

Correct answer, weight = 4
Character answer analysis
Ord - Y Subset - N Extra - N Tol - N
Input mode - Norm
Answer field 1: x = 48 y = 110
Answer field 2: x = 46 y = 140
O M
Text: x = 42 y = 72
YES
Text: x =218 y = 72
YES
Branch type - UBR, dest frame is TEN

Unexpected answer, weight = 0
Text: x =122 y = 76
NO,IT'S
Text: x =218 y = 76
M
Text: x = 42 y = 76
O
Branch type - UBR, dest frame is TEN

Frame EIGHT

Erase - Yes; Backup - NO

Match the following definitions:

1. Emission spectrum ____ UNITS OF TEM- PERATURE MEA- SUREMENT.

2. H-R diagram

3. Kelvin ____ GRAPH FOR PLOTTING STARS TEMPERATURE & BRIGHTNESS.

4. Angstrom

USE THE ARROW KEYS AND PRESS ENTER.

____ UNITS OF WAVE- LENGTH MEASURE- MENT.

Perf/Branch

Correct answer, weight = 6
Numeric answer analysis
Ord - Y Subset - N
Input mode - Norm
Answer field 1: x = 180 y = 60
Answer field 2: x = 179 y = 105
Answer field 3: x = 179 y = 145
3 2 4
Text: x =138 y = 88
YES
Text: x =138 y =120
YES
Text: x =138 y =160
YES
Branch type - UBR, dest frame is NINE

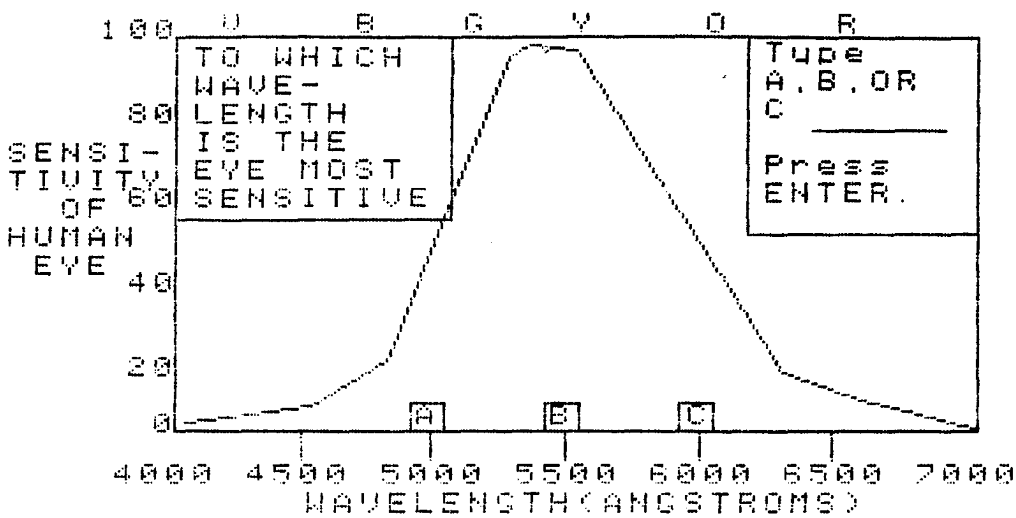
Unexpected answer, weight = 0
Text: x = 94 y = 92
NO,
IT'S
Text: x =166 y = 60
3
Text: x =166 y =106
2
Text: x =164 y =147
4
Text: x =138 y =112

Text: x =138 y =136

Branch type - UBR, dest frame is NINE

Frame FIVE

Erase - Yes; Backup - NO



Perf/Branch

Correct answer, weight = 4
Character answer analysis
Ord - Y Subset - N Extra - N Tol - N
Input mode - Norm
Answer field 1: x = 250 y = 40
B
Text: x =154 y =120
YES
Branch type - UBR, dest frame is SEVEN

Unexpected answer, weight = 0
Text: x =138 y = 96
NO,IT'S
B
Branch type - UBR, dest frame is SEVEN

APPENDIX E

RETENTION TEST

RECALL TEST

1. Suppose you observe a bluish star and a reddish star in the sky. State which is hottest.

   ____

2. Earth's atmosphere is transparent to which <u>three</u> waves in the wavelength bands.

   a. Gamma
   b. radio
   c. X-rays
   d. infrared
   e. optical(visible)

   (Circle the correct answers.)

3. The purpose of a spectrograph is to:

   1. Conduct visual observations of the stars
   2. Separate and photograph the individual wavelengths in a beam of light.
   3. Divide the stars into orbital patterns for classification purposes.

   (Circle the correct answer.)

4. Match the following:

   1. H-R Diagram
   2. Apparent Magnitude
   3. Absolute Magnitude
   4. Kelvin degrees
   5. Spectral classification

   ----- O,B,A,F,G,K,M

   ----- Unit of temperature measurement

   ----- The brightness of star as it appears in the sky.

   ----- Graph that shows brightness versus temperature for stars

5. What basic property of a star determines it position on the Main Sequence of the H-R Diagram; that is what determines its brightness and temperature?

   ____

6. FOUR NEARBY STARS

	STAR	Apparent Magnitude	Absolute Magnitude	Spectral Class
1.	Alpha Centauri	0.0	4.4	G
2.	Alpha Draco	4.7	5.9	K
3.	Barnard's Star	9.5	13.3	M
4.	Altair	0.8	2.2	A

Which star is hottest ------ Which star is coolest----
Faintest appearing ----- Actually brightest -----

7. MATCH THE FOLLOWING

1. Hydrogen into helium
2. Protostar
3. M spectral type
4. Helium flash

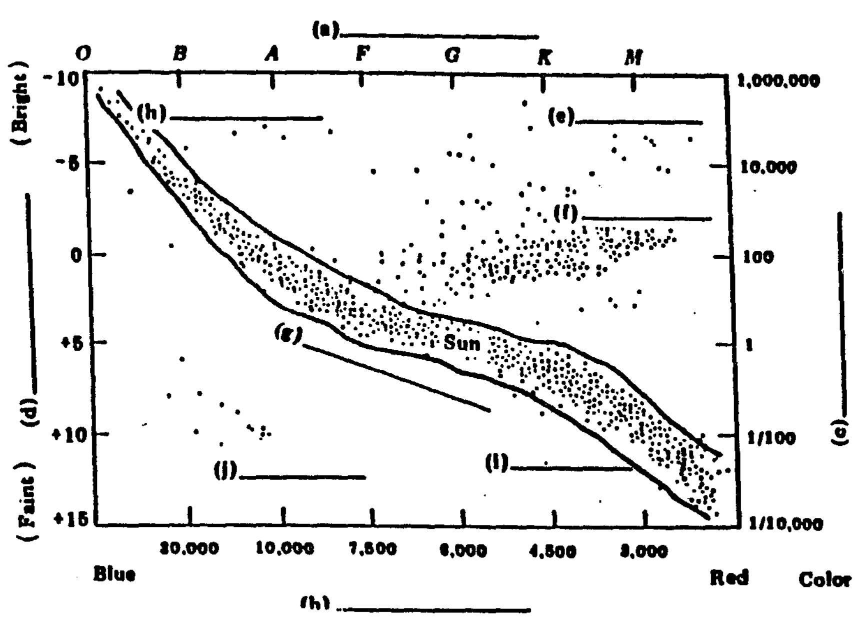
---- Main sequence star that will live the longest.

---- Chemical reaction inside core of a star.

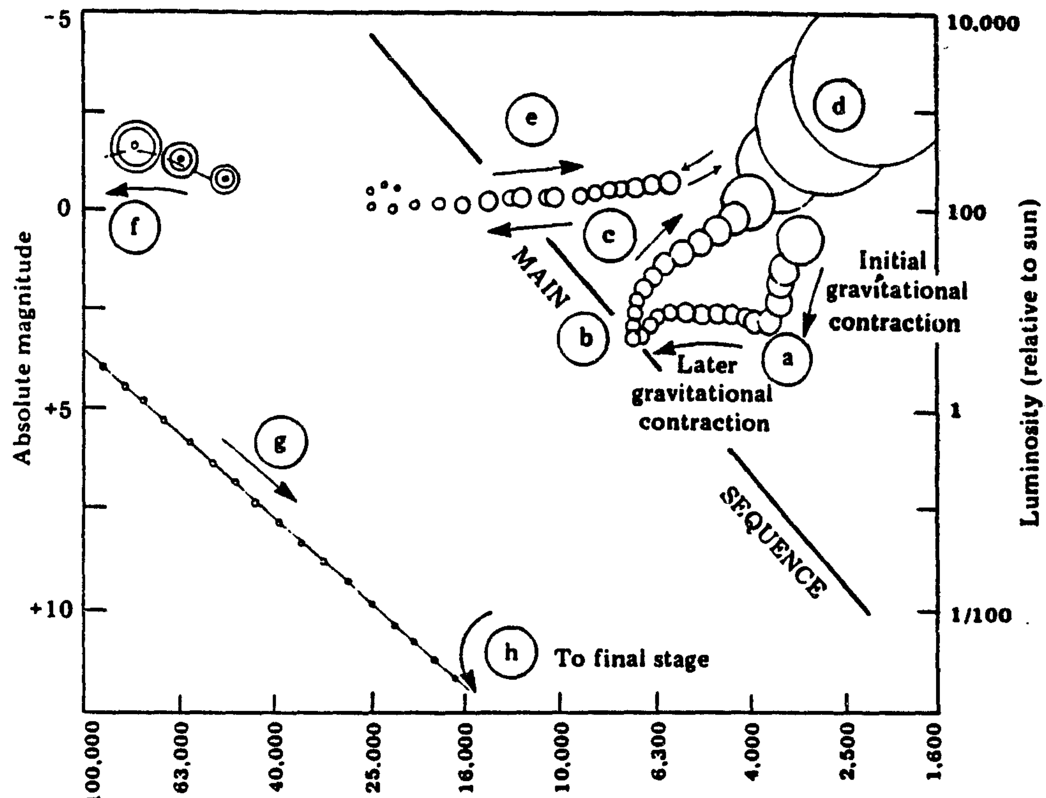
---- gravitational contraction of nebula to form a new star.

8. Label the following on the H-R diagram below:

1. red giants
2. white dwarfs
3. supergiants
4. blue giants
5. red dwarfs



9. Identify each stage of the life of a star like our sun, as labeled sequentially below:



------ Red giant, shining by helium burning

------ Evolution to red giant when helium core forms

------ Planetary nebula, hydrogen envelope ejected into space

------ Dead black dwarf in space

------ Protostar - gravitational contraction of cloud of gas and dust.

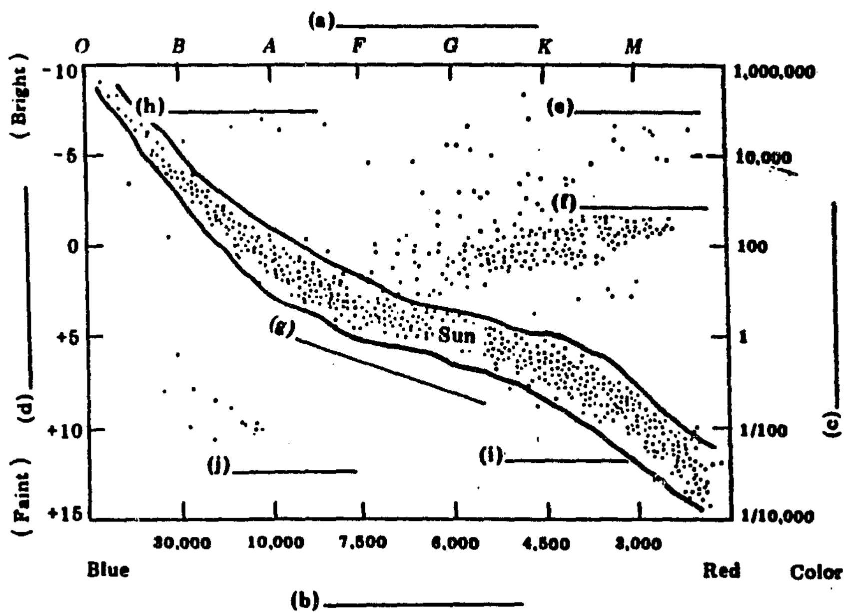
------ Stable main sequence star shining by nuclear fusion (converting hydrogen into helium)

------ White dwarf, mass packed into star about the size of earth

------ variable star, formation of carbon core

10. Label the following on the H-R Diagram below:

1. surface temperature of star (K)
2. absolute luminosity (sun=1)
3. spectral class
4. absolute magnitude
5. main sequence



NAME: ______________________________

APPENDIX F

CONCEALED FIGURES TEST