AN EXPERIMENTAL INVESTIGATION ON THE EFFECTS OF LEARNING STYLE
AND PRESENTATION METHODS ON KNOWLEDGE ACQUISITION
IN A UNIVERSITY CLASSROOM ENVIRONMENT

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By
Youngtae Ryu, B.B.A., M.B.A.

Denton, Texas
December, 1997

The purpose of this study was to investigate the effects of four learning styles (accommodator, assimilator, converger, and diverger) and two different presentation methods (traditional and computer-based) on knowledge acquisition in a university classroom. It was hypothesized that there would be main effects in both learning style and presentation methods. It was also hypothesized that there would be interaction effects between learning style and presentation methods. The subject content used for delivery of knowledge in this study was an “Introduction to the Internet.”

A total of 156 subjects from a population of students at the University of North Texas voluntarily participated in this study. Kolb’s LSI-1985 was used to identify the learning style of the individuals. Presentation methods were assigned based on the classroom setting which students were attending. In each class, a subject matter expert delivered the lesson. As a performance measure, a 20-item multiple choice test was administered immediately after the lesson.

The 2 x 4 factorial model with interaction was used in this study. Due to the unequal cell sizes, the data were analyzed using the GLM procedure of SAS. Results showed that presentation methods, learning style, and their interaction had significant
effects on knowledge acquisition. Therefore, an in-depth post hoc analysis was followed.

Post hoc multiple comparison tests for learning style showed significant differences between assimilator and accommodator or diverger. For the interaction effects between learning style and presentation methods, a simple main effect test was conducted. Results revealed that students, identified as accommodator and converger, had significantly different performance levels on knowledge acquisition between computer-based presentation and traditional presentation. Strength of associations between the knowledge acquisition performance and the two independent variables showed medium associations. The power of the treatment effects was analyzed using a SAS macro.

This study provides empirical evidence for the use of instructional technology in the classroom with specific learning styles. The outcome of this study supports the need for matching instructional treatment with individual learning style differences. However, further research is needed to generalize the results of this study. It is suggested that future researchers continue to improve the measurement for individual differences. Also, this study may be replicated with other subjects and different lessons. Furthermore, other instructional technologies beyond computer-based presentation need empirical evidence to be implemented in the educational institutions.
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CHAPTER I

INTRODUCTION

Human Resources Development managers have identified training and development as an important management area because of limited and valuable human resources. In training and development, instructional delivery is one of the three major phases: Instructional Design, Instructional Delivery, and Instructional Evaluation. When trainers or instructors deliver information to trainees or students, they have many alternatives for presentation. The knowledge acquisition process is dependent upon the way information is presented. Also, student learning differs because student learning traits differ and because the thinking process differs depending on what the student is trying to learn.

Bostrom, Olfman, & Sein (1990) report that, “A consistent pattern of findings indicates that learning mode is an important predictor of learning performance, both by itself and in interaction with training methods. This finding suggests that in the design of training, it is essential to match training methods to individual difference variables”. To enhance learning, instructors and trainers must recognize that individuals learn differently, and what may be an optimal learning or training method for one may discourage another. Indeed, instructors and trainers should make sure that a variety of training or learning opportunities are presented to students and trainees to increase the likelihood of effective learning.
Leidner and Jarvenpaa (1995) conclude that technology can be used to facilitate the display of information for subject content, to increase access to external explicit information, and to increase the sharing and construction of knowledge. By studying the interactions of the technology with individual differences, as well as the instructional technology itself, the instructional designer can draw a picture for alternative implementations of information technology in education.

Purpose

The purpose of this research was to investigate the effects of learning style and presentation methods on knowledge acquisition. Specifically, this research was an in-depth experimental investigation of the effects of learning style and presentation methods on knowledge acquisition in a university environment. This study examined the learning or knowledge acquisition, presentation methods, and instructional technology involved in the instructional delivery.

Computers have changed life on college campuses, but they still have not replaced the lecture as the predominant mode of instruction. Faculty and students use computers for their individual work, but they have had minimal collective impact on the curricula or on teaching techniques. In a conference on instructional technologies, William Feigelman and Thomas Taylor of Nassau Community College commented: “Against the backdrop of these changes, it is remarkable that instruction in undergraduate introduction to sociology courses remain virtually unchanged from what it was 25 years ago” (Burke, 1995).
There were several goals for this study. The first goal was a detailed investigation of the relationship between learning style and knowledge acquisition to improve the effectiveness of the learning process. Second, the study sought to investigate the question of how the information presentation methods can affect knowledge acquisition. A final goal was to determine if there were any interaction effects between learning style and presentation methods in knowledge acquisition.

Problem

Before providing training, it is important to know something about the needs of the trainee and the characteristics of the learner. Many factors impact how well people learn. These influences include age, intelligence, learning environment, reason for learning, beliefs and attitudes, personality, instructional technology, and learning style.

While few doubt that information technology (IT) has the potential to enhance teaching and learning, there is no agreement on how that technology should be used to boost academic productivity. Massy and Zemsky (1995) observed that the demand for IT-based teaching and learning programs will grow substantially, probably exponentially, over the next decade. Information technology will change teaching and learning profoundly, no matter what the response of traditional higher education institutions.

The problem motivating this study was that one cannot be an effective trainer or instructor without a thorough knowledge of the subject matter, but to possess that knowledge does not guarantee the ability to communicate it to a trainee or a learner (Wooldrige, 1995). Some researchers believe that the concept of learning style "is the most important concept to demand attention in education in many years and is the core of
what it means to be a person" (Guild & Garger, 1985). Studies have shown that identifying a student's learning style and providing appropriate instruction in response to that style can contribute to more effective learning (Claxton & Murrell, 1987).

Wooldrige (1995) suggests that university academic departments must become interested in making learning style research an important part of the teaching and learning process. Such interests can integrate the results of learning style research into the design and delivery of courses. Specifically, he proposes some future research efforts regarding the implication of learning style for the use of technology in delivery of higher education and the implication of individual learning style differences for the selection of the most effective instructional instrument for different types of learning objectives.

The writing board has remained the primary teaching technology in many educational institutions for a long time period. Currently, a more popular instructional technology is to use an overhead projector with transparencies in the traditional classroom. Some educational institutions have begun to build computer-based instructional classroom facilities that incorporate modern information technology in the learning and teaching processes. But there is still not much empirical evidence to support this kind of investment.

The research questions being addressed in this study were: "Are there any significant differences in knowledge acquisition by learning style?", "Are there any significant differences in knowledge acquisition by presentation methods?", and "Are there any interactions between learning style and presentation methods in knowledge acquisition?"
Significance of Study

Kolb (1984) identified four learning styles based on his experiential learning theory: accommodators, divergers, assimilators, and convergers. These four learning styles represent the majority of students, each being placed at different levels of intensity. What this means to educators is that once it is understood that differences in learning styles exist, then it will be more beneficial for the student if activities are provided that are best suited to stimulate the individual student (McKenna, 1990). It is clear that different students are likely to learn at different levels of effectiveness according to the methods used (Rockman, 1992; McKenna, 1990).

On the other hand, current practices in training and development must take into account all available technology. Bell and Elmquist (1992) indicated that education has lagged behind industry in the exposure and use of technology. Schools now have options to adopt a variety of technology for instruction such as computer-based instruction, computer-managed instruction, or distance learning. With the growing use of computers in the training and development area and the ever increasing emphasis on learner-oriented instruction, it is important that instructional designers have accurate empirical evidence regarding the relationship between individual differences and instructional design.

The new information technologies present a critical challenge to colleges and universities. They may not succeed or even survive if they ignore new technologies. The students taught today and, even more importantly, those taught in the future differ dramatically from those on which the classic college curricula and faculty teaching
techniques were built. The solution to the new technology challenge is to use new information technologies to transform classrooms and teaching techniques.

The most significant contribution of this research was to focus attention on the presentation methods used in instructional delivery. The results determine whether or not presentation formats should be matched to the student's learning style. Through the rise of psychology, learning behaviors and types, learning styles have become increasingly significant for educators. More specifically, this research intended to provide empirical evidence in facilitating effective instructional technology in the classroom and training environments. This study sought to determine the relationship between learning style and presentation methods for effective instructional design and instructional delivery.

With the increasing use of computers as a preferred instructional medium in training and development, this research sought to determine some of the conditions necessary for effective instruction. Thus, this research provides validated evidence of the link between learning style and presentation methods on knowledge acquisition.

**Definition of Terms**

For the purpose of this study, a brief description of the key terms is provided.

**Knowledge Acquisition:** In this study knowledge acquisition can be used with learning interchangeably. According to Kolb (1984), it is defined as the process whereby knowledge is created through the transformation of experience.

**Learning Style:** Individual style of learning is complex and not easily reducible into simple typologies. However, learning style is defined as characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how
learners perceive, interact with, and respond to the learning environment (Keefe, 1979). In this study, Kolb's (1984) four learning-style types (accommodator, diverger, converger, and assimilator) were identified and analyzed. There is no right or wrong learning style. Thus, in this study, an identified learning style is a preferred learning style; in other words, the mode students prefer when acquiring knowledge.

**Accommodator:** The accommodative learning style emphasizes concrete experience and active experimentation. The greatest strength of accommodator lies in doing things, in carrying out plans and tasks, and getting involved in new experiences.

**Assimilator:** In assimilation, the dominant learning abilities are abstract conceptualization and reflective observation. The greatest strength of assimilator lies in inductive reasoning and the ability to create theoretical models, in assimilating disparate observations into an integrated explanation.

**Converger:** The converger relies primarily on the dominant learning abilities of abstract conceptualization and active experimentation. The greatest strength of the convergent learning style lies in problem solving, decision making, and practical application of ideas and theories.

**Diverger:** The diverger emphasizes concrete experience and reflective observation. The greatest strength of the divergent learning style lies in imaginative ability and awareness of meaning and values.

**Learning Style Inventory:** The Learning Style Inventory (LSI) evaluates the way students learn and how students deal with ideas and day-to-day situations in students'
lives. In this study, Kolb’s Learning Style Inventory -1985 (KLSI-1985) was utilized to identify an individual learning style.

**Presentation Methods:** Knowledge acquisition process is affected by the way information is presented. In this study, two different presentation methods (computer-based presentation and traditional presentation) were applied and analyzed.

**Computer-Based Presentation:** Students in the computer-based presentation class received instruction from the instructor via an IBM-compatible computer in conjunction with a color liquid crystal display (LCD) panel. The LCD panel is placed on an overhead projector, and the PC display is shown on the screen. Students can access the Internet to exercise some applications.

**Traditional Presentation:** The traditional presentation was prepared for delivery information using a lecture with transparencies and an overhead projector. The presentation was not supported with any electronic integrated media.
CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter provides the theoretical and empirical bases for the consideration of learning style and information presentation methods as relevant variables in this instructional research. First, an overview of research in learning and instruction is presented followed by individual differences and learning style. Specific attention is given to learning style instruments. Second, the research of information presentation methods and learning will be described. The various presentation formats related to improving learning outcomes will be included here. Third, the uses of instructional technology will be discussed, especially those related to information presentations. Finally, a variety of presentation software will be reviewed.

Learning and Instruction

Learning theories provide a base for instruction to improve training programs. Robey and Taggart (1982) suggest a biological explanation for individual differences in problem solving. The brain exhibits hemispheric specialization. The right brain is utilized for intuitive, spatial, and creative processing while the left side of the brain favors rational and analytic processing. The principles of neurolinguistic programming (NLP) can help trainers teach employees (Weisburgh, 1990; Dastoor, 1993). NLP is a model for understanding human behavior and a set of communication and learning techniques, based on the belief that people have preferred modes of acquiring and processing
information. The seven intelligences (Gardner, 1983) provide another way to categorize and understand individual abilities and preferred learning methods. Kolb’s (1984) experiential learning theory identifies four stages of learning that require four learning abilities. The Color Code is a theory of personality that can help trainers and managers understand the behavior of their trainees, as well as their own behavior (Wormald, 1993). These theories can help managers and trainers understand, appreciate, and enjoy differences in the individuals with whom they work.

Theories of learning and instruction should be able to provide a framework enabling the search of its possibilities and an assessment of potential uses of the technology. Wood (1995) outlines these theories and their principal implications for the role of educational technology to support instruction and learning. These theories are Skinner’s neo-behaviorism, Piaget’s constructivist theory, and Vygotsky’s social constructivism. With Skinner’s theory (Skinner, 1968), negative reinforcement (e.g. criticism, punishment) was to be avoided. Only positive reinforcement is theoretically sound, and this must be administered according to specific schedules to ensure effective learning. Where Piagetian theory (Piaget & Inhelder, 1969) emphasizes the role of self-discovery and peer collaboration, Vygotskian theory (Wertsch, 1985) stresses the role of interactions between novices and experts.

Learning is a complex process. Jonassen and Grabowski (1993) describe learning as a condition where the student is willing or motivated to learn, where the student is able to learn, where the student is in a social and academic environment that fosters learning, and where the instruction that is available is comprehensible and effective for the learner.
Thus, individual differences and adapting instruction to individual differences are considered as important research areas. In an ideal training and development environment, the instructional system should match the learners’ characteristics. Unfortunately, this match rarely occurs (Schunk, 1991).

Learning models are often classified as being behavioral or cognitive (Leidner & Jarvenpaa, 1995). They review learning models and highlight the more widely accepted models of learning related to the use of information technology in an educational setting:

Objectivism, also referred to as the traditional model of learning, is the behavioral model of learning and represents a traditional view of learning.

The primary competing cognitive model is constructivism. The constructivist model has a number of derivations including collaborativism and cognitive information processing. The socioculturalism model shares some assumptions and goals with constructivism, but challenges some others. (p. 266)

Constructivism and cognitive information processing provide the base for this study. Basic premise of constructivism is that learning is a process of constructing knowledge by an individual. From constructivism, cognitive information processing was derived. The proposition of this model is that learning is the processing and transfer of new knowledge into long-term memory. A major assumption of the cognitive information processing model is that learners differ in terms of their preferred learning style. Instructional methods that match an individual’s learning style will be the most effective (Bovy, 1981). This suggests the need for individualized instruction.
Individual Differences and Learning Style

Individual differences play an important role in learning and instruction (Jonason & Grabowski, 1993). Every learner filters instructions through a set of individual difference filters or lenses. Individual difference filters may prevent the mental assimilation or accommodation of ideas by the learner. Individual difference lenses will focus the skills and content in ways that will affect how each individual learns. The effects of those differences are universal.

Awareness of individual differences will make educators (teachers and instructional designers) more sensitive to their role in the learning process. At the very least, this awareness may provide educators with a better understanding of difficulties that arise for certain learners in relation to specific tasks. Each individual possesses a unique pattern of mental abilities. These patterns of abilities are known as the various cognitive controls, cognitive styles, and learning styles. Also, each individual can be different in intelligence, personality, and prior knowledge.

Both cognitive controls and cognitive styles reflect patterns of thinking in learners, and both may be described as components of personality. Intelligence, intellectual aptitudes for learning, is too complex, yet too vague, and cannot be correlated with specific learning requirements of instructional approaches. Personality describes how an individual interacts with his or her environment and especially with other people. Prior knowledge does not describe the ability to know or one's preferred mode of coming to know -- just what the individual already knows. When learners interact with various modes of instruction, they develop preferred patterns for engaging the physical, mental,
and emotional requirements imposed by those learning modes. These are known as learning style.

The concept of learning style used in this study was mainly based upon Kolb’s experiential learning cycle theory. Kolb (1984) saw learning as a circular process where learning is viewed as a series of experiences with cognitive additions: 1. Concrete Experience (CE), 2. Reflective Observation (RO), 3. Abstract Conceptualization (AC), and 4. Active Experimentation (AE). Honey and Mumford (1986) extended Kolb’s theories into a psychological framework. Based on Kolb’s theories, McCarthy (1990) linked learning to the way a brain works. To improve their classroom skills, trainers need to understand how learners learn.

Learning Style Instruments

Campbell (1991) has noted that there are at least 32 commercially published instruments being used by researchers and educators to assess the different dimensions of learning style. Kolb (1976) introduced a measurement of learning styles by means of a self-description questionnaire known as the Learning Style Inventory (LSI). Honey and Mumford (1982) have developed an alternative to Kolb’s inventory that they call the Learning Style Questionnaire (LSQ). Career counselors often use the Myers-Briggs Type Indicator (MBTI), which has multiple applications and a personality profile of the individual. The Jacobs-Fuhrmann Learning Inventory is of special interest to training and development practitioners because it assesses the styles of both trainers and trainees (Ament, 1990).
Curry (1987) presented a paper that reviewed the major learning style theories and inventories in order to critically present the reliability and validity of the various learning style instruments. Based on this work, Hickcox (1995) reviewed eighteen of the 21 learning style inventories. The overall psychometric ratings for reliability and validity of the inventories are summarized in Table 1.

Table 1

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<th>Validity</th>
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There are many different types of learning style indicators, and many approaches used to construct instruments to determine the learning style of individuals. It is beyond the scope of this research to list all of them. Among those a representative sample of the leading instruments reported in the literature and used in the last fifteen years is described in this section.
Kolb's Learning Style Inventory (LSI)

Kolb (1976, 1984) developed a cycle of learning based on two bipolar dimensions of cognitive growth: the active-reflection dimension and the abstract-concrete dimension. It involves four adaptive learning modes: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). Abstract-concrete dimension represents how humans grasp experiences, information, and ideas: thinking or feeling. Active-reflective dimension represents how we transform or process experience, information, or ideas: doing or watching. These relationships are shown in Figure 1.

![Figure 1. The Cycle of Learning and Learning Style](image)

Concrete experience emphasizes feeling rather than thinking, and uses an intuitive approach rather than a systematic, scientific approach to problems. Reflective
observation focuses on the meaning of ideas and situations through observation and understanding rather than practical application. Abstract conceptualization emphasizes thinking as opposed to feeling, and has a concern with theory building rather than intuitive understanding. Active experimentation emphasizes influencing people and change through practical applications rather than reflective understanding.

Kolb introduced a measurement of learning styles by means of a self-description questionnaire known as the Learning Style Inventory (LSI) based on these four learning modes. The LSI instrument generates scores that identify four different types of learners as illustrated in Figure 1: Accommodators, Divergers, Assimilators, and Convergers.

Accommodators are action-oriented and like to solve problems in an intuitive, trial-and-error manner. They prefer concrete experience and active experimentation. Divergers have strengths in imagination and the ability to see problems from multiple perspectives. They prefer concrete experience and reflective observation. Assimilators have the ability to create theoretical models and reason inductively to the problem. They tend to be more concerned with abstract concepts and reflective observations. Convergers have strengths in the practical application of ideas. They are good at abstract conceptualization and active experimentation.

Honey and Mumford’s Learning Style Questionnaire (LSQ)

Honey and Mumford (1986) developed an instrument, called the Learning Styles Questionnaire (LSQ), to establish the degree to which an individual or group has preferences for one or more learning styles based upon Kolb’s experiential learning theory. They have identified four styles of learning: Activists, Reflectors, Theorists, and
Pragmatists. Activists learn best from activities in which they can engross themselves in short here-and-now activities. Reflectors learn from activities in which they have the chance to review what has happened and what they have learned. Theorists benefit from activities where what is being offered is part of a system, model, concept, or theory. Pragmatists learn best when there is an obvious link between subject matter and the problem or opportunity on the job.

Standing and Shevels (1994) conclude that Honey and Mumford's descriptions are more user friendly than Kolb's, although the LSQ is based on Kolb's four-stage learning process idea. They also suggest that a student/adult learner management system using Honey and Mumford's learning style questionnaire maximize learning in groups for the benefit of learners and learning institutions.

**Myers-Briggs Type Indicator (MBTI)**

The MBTI is one of the most popular instruments in the area of self-description inventories. It is based upon the theoretical psychology principals posed by Jung (1923). This indicator diagnoses the learner's preference for perceiving meaning, expressing values and commitment, and interacting with the world. According to MBTI, an individual's personality is said to be structured by preferences in the four areas: extroversion/introversion, judging/perceiving, sensing/intuition, and thinking/feeling.

**Witkin's Group Embedded Figures Test (GEFT)**

The GEFT has been used in search of simpler measures of cognitive style. The test presents a series of geometric figures, each of which contains an embedded figure that the subject must try to find. This is a test of ability to find a simple form when it is
hidden within a complex pattern. "Field independent" persons are those who successfully solve more of these figures. Subjects are able to separate the figure from its ground better than "Field dependent" persons.

Information Presentation

Past research has indicated that the information acquisition process is dependent upon the way information is presented (Livergood, 1994; Wilson & Addo, 1994; Tan & Benbasat, 1993; Carey & White, 1991; Jarvenpaa, 1989; Garceau, Oral, & Rahn, 1988; Benbasat & Dexter, 1985 & 1986). Livergood (1994) compared the effectiveness of three instructional delivery systems: printed materials, a computer-based multimedia program, and a multimedia modified intelligent tutoring system. Tan and Benbasat (1993) conducted experiments to assess the relative strengths and weaknesses of bar, symbol, and line graphs for performing a variety of elementary information extraction tasks using two dependent variables, time and accuracy. Jarvenpaa (1989) investigated the effects of graphical formats and task demands upon decision processes and decision outcomes. Garceau, Oral, and Rahn (1988) developed a framework for the presentation of data to compare the effects of using tabular and graphic protocols. Coll and Coll (1993) presented the message that the user's performance is determined by other factors interacting with display presentation format and that to study display presentation format in isolation is incomplete.

Hoadley (1990) investigated the effects of color on performance in information processing. She found that color improved time performance and accuracy performance with specific graphical presentation formats. Benbasat, Dexter, and Todd (1986) have
conducted a series of lab experiments to examine the color effects with individual
difference and task settings. The authors found main effects of color performance
measures and user preferences as well as interaction between personality and color.
Gremillion and Jenkins (1981) examined the effects of color-coded transparencies on
information retention from a lecture. The finding showed a significant improvement in
recall with color in a comprehension and learning task.

Anyone attending various conferences and seminars will be impressed with the
variety of technology used to deliver presentations to audiences. Slides and
transparencies with color and graphics are common, and one sees the increasing use of
computer-generated visual displays from laptops and computer screen projectors. These
high-tech presentations with color and graphics are very entertaining and are much more
likely to hold one’s attention than presentations that consist simply of black text on empty
glaring white projection screens (Phillips, 1994). Also, the incorporation of multimedia
tools and techniques such as sound and video, as well as graphics, can help create truly
impressive presentations.

Information Technology and Instructional Technology

Information technology is slowly becoming a part of educational classrooms and
corporate training facilities (Leidner & Jarvenpaa, 1993). Piskurich (1993) states that
many things happening in instructional technology today will directly affect us in the near
future. Powerful notebook-size computers, CD-ROM drives, the ability to provide
interactive lessons on standard off-the-shelf equipment, digital video interactive (DVI),
networked simulators, and continued miniaturization and cost-reduction of equipment are all hardware advances that have vast implications in the coming years.

At the same time, software based on HyperCard, its clones, and its descendants will shape our instructional design abilities and possibilities for some time to come. A number of presentation software packages, including Microsoft's PowerPoint, enable presenters to shape instructional design, courseware creation, faculty development, and media services in support of teaching and learning.

Instructional technology is a computer-based and systematic approach to documentation and presentation of concepts, theories, and procedures for the purpose of instruction (Kasravi, 1994). Russell (1994) introduced a book, edited by Piskurich, called *The ASTD Handbook of Instructional Technology*. He made the assertion that the authors have a wealth of global and domestic expertise in instructional design and technology, corporate training, management development, computer-based training, electronic media, and human resource development.

Technological advancements are beginning to combine the worlds of traditional media and computers. Classrooms are moving toward a day when they will have a full range of audiovisual, computing, and data projection equipment where the resident computer is both a control device and a presentation device (Mitchell, 1990). However, technology should be viewed not as an end in itself, but as a potential tool to support the educational process.
Presentation Software

One of the biggest changes in presentation graphics in recent years is that the software is often bundled with the office package and the PC to run fairly sophisticated effects (Rines, 1995). This bundling has made Microsoft's PowerPoint, which comes with the company's office package, the most widely used presentation software. The next most popular packages are Lotus Freelance, which is also available as part of a bundle, and SPC's Harvard Graphics, which is sold on its own. For Apple Macintosh users the leading package is Persuasion.

Levitt (1995) reviewed three potent, cross-platform, multimedia business presentation software packages: Microsoft's PowerPoint, Gold Disk's Astound, and Adobe Systems' Persuasion. In his review, he concluded that “PowerPoint is certainly the easiest for beginners to use. However, it lacks depth in multimedia support and tools. Astound offers the most sophisticated multimedia support. Persuasion falls in the middle in terms of functionality and ease of use.”

Fridlund and Harney (1994) reviewed four leading desktop presentation software packages for Windows: Lotus Development Corporation's Freelance Graphics, Software Publishing Corp.'s Harvard Graphics, Microsoft Corporation's PowerPoint, and Novell Applications Group's (formerly WordPerfect Corporation) WordPerfect Presentations. Based on this review, there are not many differences among those software packages except WordPerfect Presentations. As shown in Table 2, WordPerfect Presentations has the highest grade only in the area of documentation.
<table>
<thead>
<tr>
<th><strong>Performance</strong></th>
<th><strong>Freelance Graphics</strong></th>
<th><strong>Harvard Graphics</strong></th>
<th><strong>PowerPoint</strong></th>
<th><strong>WordPerfect Presentations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Presentation Setup and Report</strong></td>
<td>Satisfactory</td>
<td>Good</td>
<td>Very Good</td>
<td>Satisfactory</td>
</tr>
<tr>
<td><strong>Slide Creation</strong></td>
<td>Very Good</td>
<td>Very Good</td>
<td>Good</td>
<td>Satisfactory</td>
</tr>
<tr>
<td><strong>Text Handling</strong></td>
<td>Good</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Satisfactory</td>
</tr>
<tr>
<td><strong>Slide Editing and Embellishing</strong></td>
<td>Good</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Satisfactory</td>
</tr>
<tr>
<td><strong>Presentation Management</strong></td>
<td>Very Good</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Slide-Show Capabilities</strong></td>
<td>Satisfactory</td>
<td>Good</td>
<td>Good</td>
<td>Satisfactory</td>
</tr>
<tr>
<td><strong>Multimedia Capabilities</strong></td>
<td>Excellent</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Very Good</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Very Good</td>
</tr>
<tr>
<td><strong>Support Policies</strong></td>
<td>Very Good</td>
<td>Good</td>
<td>Very Good</td>
<td>Very Good</td>
</tr>
<tr>
<td><strong>Technical Support</strong></td>
<td>Satisfactory</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
</tr>
<tr>
<td><strong>Value</strong></td>
<td>Very Good</td>
<td>Excellent</td>
<td>Very Good</td>
<td>Satisfactory</td>
</tr>
</tbody>
</table>
CHAPTER III

METHODS AND PROCEDURES

This section describes the methods and procedures used, beginning with the identification of the subjects who participated in the study. This is followed by a description of the research design, which establishes the independent variables and dependent variables. Next, instruments used in the study are described. Then, the procedures to collect data, statistical analysis, and the hypotheses to be tested are presented. Finally, limitations and assumptions of this research are described.

Subjects

The target population of the study was college students at the University of North Texas (UNT), Denton, Texas. The university has a total of approximately 25,000 students. Subjects were selected from this total population by using a cluster sampling method. It was more feasible and convenient to select groups of individuals than to select individuals from a defined population. Classrooms were selected based upon the instructor's cooperation. Subjects came from a variety of majors and three different colleges: College of Education, College of Business Administration, and College of Arts and Sciences. A total of 10 classes, 6 traditional presentations and 4 computer-based presentations, participated in this study for a sample size of 156. Participation in the study was voluntary and there was no extra credit granted for participation. The subjects in this study were not exposed to any unreasonable discomforts, risks, or violations of
their human rights. However, an approval to conduct this study was received from the
Institutional Review Board for the protection of Human Subjects in Research at the
University of North Texas. By the requirement of this Review Board, all participants
signed an Informed Consent Form (See Appendix A for a copy of the Informed
Consent Form).

Research Design

Each student has their own aptitude and learning style. Therefore, a specific
method of instruction may not be effective for all students. Effectiveness of learning or
training may result from efforts to match instructional methods (instructional design,
instructional delivery, and instructional evaluation) with students who are best able to
learn from them. A line of educational experimentation which is called aptitude
treatment interaction (ATI) research has explored this possibility (Borg & Gall, 1989).
The purpose of ATI research is to determine whether the effects of different instructional
methods are influenced by the cognitive or personality characteristics of the learner.
Thus, this research followed the baseline of the ATI research.

According to the ATI research, it does not assume that one instructional method is
better than another. It is also not assumed that students with certain characteristics are
better learners than others. Instead, ATI research takes the assumption that the two
factors (instructional method and learner characteristics) may interact in some ways that
have educational significance.

This study utilized a quasi-experimental design known as the nonequivalent
control group design (Campbell & Stanley, 1963). It involved comparisons between an
experimental group and a control group. The experimental group participated in a computer-based presentation and the control group participated in a traditional presentation. Both groups were given a test to measure achievement of knowledge acquisition. The Learning Style Inventory (LSI) was also administered to identify the learning style of each student.

A factorial design with two treatments was used for the analysis. The two treatments were learning style and presentation methods. The study utilized the fixed-effects model because the researcher selected specific levels of interest for both treatments, learning style and presentation methods. Four levels of learning style (Accommodators, Divergers, Assimilators, and Convergers) were crossed with two presentation methods (traditional presentation and computer-based presentation). With these two treatments, a dependant variable was the performance on knowledge acquisition.

Based upon the previous research in this area, this study assumed that a standardized effect size (d) is 0.75, a level of significance is 0.05, and power is 0.80. Table C.12 of Hinkle’s (1988) was used to determine the appropriate sample size. For the first independent variable, learning style, the sample size required for each level would be 40 with four levels. The second variable, presentation methods, with two levels, required a sample size of 19 for each level. For a two-factor design, it is necessary to satisfy the sample size requirement for both independent variables, learning style and presentation methods. Such a strategy leads to slightly larger sample sizes for the levels of both variables and to more powerful statistical tests. In order to meet the requirements
for this 2 x 4 design, with 2 x 4 = 8 cells, the sample size for each cell would be 15, as shown in Table 3.

Table 3

Sample Size Requirements

<table>
<thead>
<tr>
<th>Class</th>
<th>Learning Style</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accommodator</td>
<td></td>
</tr>
<tr>
<td>Computer-Based</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Traditional</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>120</td>
</tr>
</tbody>
</table>

Learning Style Measurement

The available research raises some questions regarding the use of Kolb's Learning Style Inventory-1976 (KLSI-1976) for purposes of research and design. A number of researchers using diverse samples obtained evidence that questions both the reliability and validity of the instrument (Ruble & Stout, 1993; Freedman & Stumpf, 1980; Hunsaker, 1984; Sewall, 1986; Atkinson, 1991).

Freedman and Stumpf (1980) conclude that the KLSI-1976 is not valid and that its use in making normative judgements about educational practices should be suspended. Hunsaker (1984) concludes that the KLSI does not demonstrate sufficient reliability to provide predictive ability. According to Sewall (1986), the validity of the KLSI-1976 had not been confirmed, and he recommends that the use of the KLSI-1976 in any setting be suspended pending further careful study. Atkinson (1991) also concludes that the KLSI seems psychometrically deficient in several areas. In response to extensive criticism, the
KLSI-1976 has been revised (Kolb, 1985). While the revised version, the KLSI-1985, appears to be an improvement in some areas, unfortunately many of the psychometric limitations of the earlier version have remained (Atkinson, 1991). Thus, Ruble and Stout (1993) conclude that even the KLSI-1985 needs further revision.

Ruble and Stout (1993) point out that the learning style instruments available today, including Kolb's Learning Style Inventory (LSI) and Honey and Mumford's Learning Style Questionnaire (LSQ), are still inadequate from a validation perspective. Obviously, the available learning style instruments require additional validation research. But as Bostrom, Olfman, and Sein (1993) recommend, important research cannot always wait for the perfect measure. There is not a perfect measurement. This is one of the reasons that this study chose one of the most popular instruments to measure learning style.

The four individual Kolb's LSI-1985 scales have shown modest internal consistency reliability. Sewall (1986) examined internal consistency reliabilities and indicates that coefficients have ranged from 0.29 to 0.81 for the individual scales with an overall average of 0.58. However, the two learning mode dimensions, concrete experience (CE) - abstract conceptualization (AC) and active experimentation (AE) - reflective observation (RO), have consistently exhibited higher reliability. He also reports reliabilities ranging from 0.66 to 0.86 in the difference scales with an overall average of 0.78. The use of Kolb's LSI-1985 was appropriate in this study because the principal variable of interest was the difference in learning modes.
The Kolb’s experiential learning theory and the LSI have been used in a variety of settings for measuring individual differences. The Learning Style Inventory used in this study was originally created by Kolb and revised in 1985 (KLSI-1985). The KLSI-1985 showed a strong reliability and fair validity (Hickcox, 1995). According to the LSI technical specification (1985), the four basic scales and two combination scores all showed very good internal reliability as measured by Cronbach’s $\alpha$ (n=268). The combination scores showed almost perfect additivity (1.0) as measured by Tukey’s test. Also, the test is brief and straightforward with clear instructions, including a helpful example. It uses simplified language at a clear, accessible reading level. For the validation issue, norms for the KLSI-1985 showed a more representative normative sample, which was ethnically diverse, drawn from a wide range of careers, with an average education of two years in college. One other reason for choosing the KLSI-1985 was that it can be easily obtained from the publisher at a reasonable price. The KLSI-1985 is a self-descriptive, self-administered 12-item inventory that assesses an individual’s orientation towards learning. It takes about 25 minutes to complete and score. It measures the relative emphasis the respondent attaches to each of four learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation. The four learning modes can be used to define four learning styles: Accommodators, Divergers, Assimilators, and Convergers. Permission to use the Learning-Style Inventory (LSI) in this research was given when the materials were purchased from the Training Resources Group at Hay/Mcber. Correspondence and permission to include a copy of the instrument in my dissertation
and a copy of the instrument are attached in the Appendix B (Learning Style Measurement).

Instructional Material

The content of instruction used in this study was an "Introduction to the Internet". It was selected as the content subject because it was considered to be relatively new and of interest to students. It was developed by the researcher. All instruction was presented at an introductory level. The instructional unit is included in Appendix C (Instructional Material).

Instructional Treatments

The instructional treatments consisted of two presentations on an "Introduction to the Internet." Two presentations were delivered corresponding to the two types of presentation methods: traditional presentation or computer-based presentation. Basically, these two presentations were created using the same computer presentation software, Microsoft's PowerPoint. The traditional presentation delivered instruction using black on clear transparencies (see Appendix D). The computer-based presentation delivered instruction using a computer slide show (see Appendix E). Instructional delivery was by means of a subject matter expert, a Campus-Wide Information Systems Coordinator (a Webmaster) of the University of North Texas. The main purpose of each class presentation was to present information on an "Introduction to the Internet".

Some special equipment was used for each presentation. An overhead projector was required for the traditional presentation. For the computerized presentation, a computer, with relevant software (MS Windows and MS PowerPoint), a mouse, an
overhead projector, and a color liquid crystal display (LCD) panel were required. Also, Internet accessibility was required for the computer-based presentation.

There are a number of presentation software packages on the market. Off-the-shelf presentation software packages can be purchased economically and are easy to use. In choosing software, it is important to consider compatibility with the computer. For this research, Microsoft's PowerPoint was selected because of its compatibility and functionality.

**Traditional Presentation**

The traditional presentation was prepared for delivery using a lecture with black on clear transparencies and an overhead projector. The presentation was not supported with any electronic integrated media. Copies of transparencies were provided to the students for their reference. Each sheet of paper in the handout contained three transparencies. The class presentation was formal and not accompanied by visual aids other than the transparencies and the writing board.

**Computer-based Presentation**

Students in the computer-based presentation class received instruction from the instructor via an IBM-compatible computer in conjunction with a color LCD panel. The LCD panel was placed on an overhead projector, and the PC display was shown on the screen. Students could access the Internet to exercise some applications.

The DOS operating system, MS Windows, and MS PowerPoint were used to create and present a computer-generated slide presentation. MS PowerPoint is a complete presentation graphics package, allowing the user to produce a professional-looking
presentation with text handling, outlining, drawing, graphing, and clip art. A PowerPoint presentation is a collection of slides, handouts, speaker’s notes, and an outline, all in one file. An electronic slide presentation was delivered to the students with a handout. Copies of slides were provided to the students for their reference. Each sheet of paper in the handout contained three slides.

Performance Measurement

After the instruction, a test consisting of 20 questions using a multiple-choice format (1 correct answer and 4 distractors) was administered to all subjects. The test was designed to measure the performance on knowledge acquisition about the subject matter content delivered. The content validity of the test was established by a group of content experts from the Computing Center at the University of North Texas. A copy of the test is attached in Appendix F.

Procedure

Ten university classes, with a total of 156 subjects, were used for the experiments. All equipment (OHP, LCD panel, and Computer) for the presentation were readied before the students came to the class. The classes were assigned to one of two instructional treatments based upon the classroom setting.

First, all participants signed an Informed Consent Form. The learning style measurement was administered at the beginning of the instruction. Next, the instructional treatments and a test for performance measure were administered. This whole process took about one two-hour class session. Five minutes was assigned for signing the
Informed Consent Form, 25 minutes for the learning style measurement, 60 minutes for the instructional delivery, and 30 minutes for the performance measure.

The data were collected and recorded in the computer for analysis. This experiment took two long semesters (Fall 1996 and Spring 1997) and two summer semesters (Summer I and II 1997) to complete. Although there was a several month time span between each experiment, it was believed that this did not contaminate the data because this experiment was not related to students' course work. Additionally, there was little possibility that the students from the different time periods would communicate with each other about the treatment, because the treatments are not normally included in the content of their classroom instruction.

Statistical Analysis

Based upon the results of the learning style inventory and two different presentations, a statistical analysis consisting of a 4 x 2 factorial analysis was administered with the SAS program. This analysis is commonly referred to as a two-way analysis of variance (ANOVA). The ANOVA procedure should be used whenever possible for analysis of variance because ANOVA processes data more efficiently than general linear models (GLM). However, GLM should be used in most unbalanced situations, that is, models where there are unequal numbers of observations for the different combinations of class variables specified in the model. This study did not guarantee the equal cell size and the data showed unequal numbers of observations for the different combinations of presentation methods and learning style. Thus, this study utilized the GLM procedure of the SAS program. First, it tested the overall model, which
tests how well the model as whole accounts for knowledge acquisition. Because a significant $F$ ratio was found for the interaction between learning style and presentation methods, a post hoc procedure, called the test of simple effects, was used in conjunction with the plotted cell means in interpreting the interaction.

Then, it tested that there exists some differences among the means of treatment levels in each independent variable, which is a test of main effects. This is sometimes called the omnibus test (Hinkle, Wiersma, & Jurs, 1988). Because a significant $F$ ratio was found in the omnibus test for learning style, post hoc multiple comparison tests were conducted. Here, the procedure determined which means differ significantly among four different learning styles. Scheffé method was used because the group sizes were unequal and a combination of means, rather than simply pairs of means, were contrasted.

A measure of the strength of the association between the independent and dependent variables ($\omega^2$, omega squared) was analyzed. Omega squared indicates the proportion of the variance in the dependent variable that is accounted for by the levels of the independent variables. Also, the power of the treatment effects test was analyzed. The power explains the probability of rejecting a false complete null hypothesis. The SAS program for this analysis is shown in Appendix G.

Hypotheses

The overall hypothesis of this study was that knowledge acquisition would vary when the classroom and the learning style were different. It was hypothesized that students would score differently on performance measures of knowledge acquisition when instruction was delivered in a format of computer-based presentation when
compared to a traditional presentation. Also, it was hypothesized that there were
significant differences in knowledge acquisition among different learning styles. Some
interactions between learning style and presentation methods were hypothesized.

The following null hypotheses were devised to test the effect of independent
variables (presentation methods and learning style) on the dependent variable (knowledge
acquisition). These hypotheses were stated in the null form. The rejection of a null
hypothesis implies that, based upon the data collected, independent variables have a
potentially significant impact on dependent variables.

H1: There is no significant difference in knowledge acquisition between the
traditional presentation and computer-based presentation.

H2: There are no significant differences in knowledge acquisition among different
types of learning styles.

H2a: There is no significant difference in knowledge acquisition between
Assimilator and Converger.

H2b: There is no significant difference in knowledge acquisition between
Assimilator and Accommodator.

H2c: There is no significant difference in knowledge acquisition between
Assimilator and Diverger.

H2d: There is no significant difference in knowledge acquisition between
Converger and Accommodator.

H2e: There is no significant difference in knowledge acquisition between
Converger and Diverger.

H2f: There is no significant difference in knowledge acquisition between
Accommodator and Diverger.
H2g.: There is no significant difference in knowledge acquisition between thinking-oriented students (Converger and Assimilator) and feeling-oriented students (Accommodator and Diverger).

H2h: There is no significant difference in knowledge acquisition between doing-oriented students (Accommodator and Converger) and watching-oriented students (Diverger and Assimilator).

H3: There are no significant interactions between students with different types of learning styles and presentation methods in knowledge acquisition.

Limitations and Key Assumptions

The diversity of learning styles needs to be considered with some care in providing instruction and training. In this study, only Kolb’s Learning Style Inventory was administered to identify students’ individual learning styles. In addition to learners preferring different learning styles, instructors and trainers have their own personal strengths, weaknesses and preferences with regard to the teaching method. This research did not consider the individual differences of instructors and trainers.

Various instructional techniques are being employed in the current teaching process (Daley, 1994). Some examples are the lecture-discussion format, expert speakers, case studies, role playing simulations, and so on. However, this research utilized the lecture-discussion format and a computer-based presentation. Thus, if any other formats were used in the instruction, the results would also be questionable.

This research was designed for college students in a single university. The results are not necessarily appropriate for other educational settings and training of more mature adult learners. This means the generalizability of the results of this study is limited.
Conducting this research with other experimental settings would enhance the significance of results of this study.

There are many factors which affect learning. This study considered two major elements: the learner’s learning style and presentation methods. Any other elements were assumed to be same. In this kind of study, prior knowledge could be a major confounding factor as pointed out by previous ATI researchers (Cronbach, 1975; Tobias, 1982).

The subject content of this study was adopted directly relevant with information technology, which was an “Introduction to the Internet”. If any other subject was used for the experiment, it could produce different results.

A key assumption of the study was how the learning style and presentation methods actually impacted on knowledge acquisition for the learners. In addition to this, the study assumed the same instructor could deliver the same instruction in all classes. It was also assumed that knowledge acquisition could be operationalized through a test. According to Bloom’s Taxonomy, there are six different levels of the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. In this study, however, only the knowledge level of the cognitive domain was included.
CHAPTER IV

RESULTS

This chapter describes the analysis and interpretation of data generated by testing hypotheses that examine the impact of presentation method and learning style on knowledge acquisition. First, the data are described. Second, statistical analysis of the results in the experiment is presented. Third, the interaction effects of pertinent variables with knowledge acquisition are evaluated and discussed. Finally, each hypothesis, as presented in Chapter III, is identified along with supporting analysis and discussion. Raw data for statistical analysis is attached in Appendix H.

Data Description

Data used in the statistical analyses were obtained from Kolb's Learning Style Inventory-1985 (KLSI-1985) and the multiple-choice test which followed each instruction. Among 156 observations, 10 were not complete. Four participants did not follow the instructions for the KLSI-1985 measurement, and six others did not return the answer sheet. These 10 observations were excluded from the analysis. Thus, this study had a total of 146 observations for analysis. Some demographic information such as college, gender, and age was collected, but they were omitted from this analysis because the subjects who participated in this experiment were the same university students with reasonably similar backgrounds.
Among 146 participated subjects, 41 were College of Business students, Ninety-three were College of Education students, and the remaining 12 students were from College of Art and Sciences. The subjects ranged between 19 and 57 years of ages with a mode of 23 years of age. And there were 76 females and 70 males in the subjects.

The dependent measure was knowledge acquisition as measured by the test scores. It was a 20 item multiple-choice test. Each question was worth one point. Means and standard deviations of the test scores along with the number of subjects for each learning style for each classroom setting are presented in Table 4.

Table 4

Means, Standard Deviations, and Frequencies

<table>
<thead>
<tr>
<th>Class</th>
<th>Stat.</th>
<th>Learning Style</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Accommodator</td>
<td>Assimilator</td>
</tr>
<tr>
<td>Computer-Based</td>
<td>M</td>
<td>11.71</td>
<td>12.00</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.86</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Traditional</td>
<td>M</td>
<td>8.75</td>
<td>11.26</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.24</td>
<td>2.66</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>16</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>M</td>
<td>10.13</td>
<td>11.46</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.14</td>
<td>2.47</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>30</td>
<td>57</td>
</tr>
</tbody>
</table>

(Note. M=Mean; SD=Standard Deviation; n=number of subjects in cell)

As shown in Table 4, most of the cells were satisfied with the requirement of cell size as shown in Table 3. There was a little shortage in the diverger group, but this did not impact on the analysis totally. However, the total sample size of 146 was enough to
meet the recommended requirement of 120.

For the test of normality, SAS Univariate procedure was used. The SAS Univariate procedure provides greater detail on the distribution of a variable. It can provide details on the extreme values of a variable, quantiles, frequency tables, several plots to illustrate the distribution, paired comparison tests, tests of central location, and a test to determine whether the data are normally distributed. Because the sample size was small, the Shapiro-Wilk statistic, $W$, was used to analyze the normality of data. Shapiro and Wilk (1965) describe the $W$ statistic as the “ratio of the best estimator of the variance (based on the square of a linear combination of the order statistics) to the usual corrected sum of squares estimator of the variance”. The result ($W: \text{Normal}=0.9654$) indicated that the sample data came from a normal distribution. The sample data distribution shown in Figure 2 shows that the scores on the dependent variable are normally distributed in the population.

![Knowledge Acquisition Score Distribution](image)

**Figure 2.** Sample Data Distribution
SAS Plot option in the Univariate procedure generated three data plots: a stem-and-leaf plot, a box plot, and a normal probability plot. They all showed that the sample data distribution did not deviate from the normal distribution, which means the sample data came from a normal distribution.

Statistical Analysis on the Results of the Experiment

The model for this experiment can be stated in terms of the function between presentation methods (Class), learning style (Style), and the interaction of presentation methods and learning style on knowledge acquisition (Score).

\[ \text{Score} = f(\text{Class, Style, Class} \times \text{Style}) \]

The F Value of the overall model, which tests how well the model as a whole accounts for the dependent variable’s (Knowledge Acquisition) behavior, is 5.86. Because Pr > F has a small significance probability (0.0001), less than 0.05, the overall model has a significance at the probability level of 0.05. The summary of the results for statistical analysis is presented in Table 4. The results show that presentation methods (Class) and learning style (Style) of students had a significant effect on knowledge acquisition (Score). However, the small R-Square (0.23) means that only 23 percent of variations in the knowledge acquisition (Score) can be explained by presentation methods (Class), learning style of students (Style), and the interaction. This indicates that other factors beyond these independent variables (presentation methods and learning style) had some influence on knowledge acquisition.
### GLM Regression Analysis Summary

**Dependent Variable: Knowledge Acquisition (Score)**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>7</td>
<td>169.7378</td>
<td>24.2482</td>
<td>5.86</td>
<td>0.0001</td>
</tr>
<tr>
<td>Error</td>
<td>138</td>
<td>570.8923</td>
<td>4.1369</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>145</td>
<td>740.6301</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Presentation Methods (Class) | 1  | 58.4143  | 58.4143  | 14.12 | 0.0003 |
| Learning Style (Style)       | 3  | 73.6397  | 24.5465  | 5.93  | 0.0008 |
| Interaction (Class*Style)    | 3  | 40.8109  | 13.6036  | 3.29  | 0.0227 |

(Note: R-Square 0.229)
Interaction Effects

The result of SAS GLM procedure indicated that interaction between presentation methods (Class) and learning style (Style) had a significant impact on knowledge acquisition (Score), $F(3, 142) = 3.29$, $p = 0.0227$ as shown in Table 5. Because a significant F ratio was found for the interaction between learning style and presentation methods, a post hoc procedure, called the test of simple effects, was conducted using contrast options in the SAS GLM procedure. For interpreting the interaction, cell means are shown in Table 6 and plotted in Figure 3.

As shown in Figure 3, the cell means for computer-based presentation were always greater than for traditional presentation across the three learning styles except one, a diverger case. The points of cell means intersect within the plot at the diverger, which indicates the interaction was disordinal. Figure 3 shows that accommodators and convergers had a better performance on knowledge acquisition in the computer-based presentation compared to the traditional presentation. Assimilators showed slightly higher performance in the computer-based presentation than in the traditional presentation. For divergers, the performance was almost the same for two different presentation methods, but the traditional presentation showed a little higher performance than the computer-based presentation. For a more detailed analysis in the interaction effects, multiple comparison tests were conducted using the SAS GLM procedure with contrast options.
Table 6

Cell Mean and Standard Deviation

<table>
<thead>
<tr>
<th>Level of Presentation Methods</th>
<th>Level of Learning Style</th>
<th>N</th>
<th>Performance Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Computer-Based</td>
<td>Accommodator</td>
<td>14</td>
<td>11.7142857</td>
</tr>
<tr>
<td>Computer-Based</td>
<td>Assimilator</td>
<td>15</td>
<td>12.0000000</td>
</tr>
<tr>
<td>Computer-Based</td>
<td>Converger</td>
<td>14</td>
<td>12.2142857</td>
</tr>
<tr>
<td>Computer-Based</td>
<td>Diverger</td>
<td>12</td>
<td>9.6666667</td>
</tr>
<tr>
<td>Traditional</td>
<td>Accommodator</td>
<td>16</td>
<td>8.7500000</td>
</tr>
<tr>
<td>Traditional</td>
<td>Assimilator</td>
<td>42</td>
<td>11.2619048</td>
</tr>
<tr>
<td>Traditional</td>
<td>Converger</td>
<td>20</td>
<td>10.3000000</td>
</tr>
<tr>
<td>Traditional</td>
<td>Diverger</td>
<td>13</td>
<td>9.8462538</td>
</tr>
</tbody>
</table>

Figure 3. Interaction Effects between Class and Style
Simple Main Effects

Interaction effects were analyzed by the simple main effects test of GLM. Regression analysis in more detail. The results are shown in Table 7. Simple main effects for presentation methods (computer-based presentation or traditional presentation) for learning styles of accommodator and converger were significant at the probability level of 0.05, $F(1, 144) = 15.86$, $p = 0.0001$ and $F(1, 144) = 7.29$, $p = 0.0078$. It suggests that accommodator students and converger students had significantly different performance scores on knowledge acquisition between computer-based presentation and traditional presentation. Simple main effects for learning style at two different classes were significant at the probability level of 0.05, $F(3, 142) = 4.18$, $p = 0.0073$ and $F(3, 142) = 6.36$, $p = 0.0005$. It suggests that different learning style students had significantly different performance scores on knowledge acquisition at each presentation method.

As shown in Table 7, in the computer-based presentation, comparison between accommodator and diverger ($p = 0.0116$), comparison between assimilator and diverger ($p = 0.0036$), and comparison between converger and diverger ($p = 0.0018$) were significant in the performance scores on knowledge acquisition. In the traditional presentation, comparison between accommodator and assimilator ($p = 0.0001$), comparison between accommodator and converger ($p = 0.0246$), and comparison between assimilator and diverger ($p = 0.0300$) were significant in the performance scores on knowledge acquisition.
Table 7

Simple Main Effects Summary

<table>
<thead>
<tr>
<th>Contrast</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class at Accommodator (Acc)</td>
<td>1</td>
<td>65.6095</td>
<td>65.6095</td>
<td>15.86</td>
<td>0.0001</td>
</tr>
<tr>
<td>Class at Assimilator (Ass)</td>
<td>1</td>
<td>6.0213</td>
<td>6.0213</td>
<td>1.46</td>
<td>0.2297</td>
</tr>
<tr>
<td>Class at Converger (Con)</td>
<td>1</td>
<td>30.1781</td>
<td>30.1781</td>
<td>7.29</td>
<td>0.0078</td>
</tr>
<tr>
<td>Class at Diverger (Div)</td>
<td>1</td>
<td>0.2010</td>
<td>0.2010</td>
<td>0.05</td>
<td>0.8259</td>
</tr>
<tr>
<td>Style at Computer-Based</td>
<td>3</td>
<td>51.8281</td>
<td>17.2760</td>
<td>4.18</td>
<td>0.0073</td>
</tr>
<tr>
<td>Acc vs Ass</td>
<td>1</td>
<td>0.5911</td>
<td>0.5911</td>
<td>0.14</td>
<td>0.7060</td>
</tr>
<tr>
<td>Acc vs Con</td>
<td>1</td>
<td>1.7500</td>
<td>1.7500</td>
<td>0.42</td>
<td>0.5165</td>
</tr>
<tr>
<td>Acc vs Div</td>
<td>1</td>
<td>27.0915</td>
<td>27.0915</td>
<td>6.55</td>
<td>0.0116</td>
</tr>
<tr>
<td>Ass vs Con</td>
<td>1</td>
<td>0.3325</td>
<td>0.3325</td>
<td>0.08</td>
<td>0.7772</td>
</tr>
<tr>
<td>Ass vs Div</td>
<td>1</td>
<td>36.2962</td>
<td>36.2962</td>
<td>8.77</td>
<td>0.0036</td>
</tr>
<tr>
<td>Con vs Div</td>
<td>1</td>
<td>41.9377</td>
<td>41.9377</td>
<td>10.14</td>
<td>0.0018</td>
</tr>
<tr>
<td>Style at Traditional</td>
<td>3</td>
<td>78.9446</td>
<td>26.3148</td>
<td>6.36</td>
<td>0.0005</td>
</tr>
<tr>
<td>Acc vs Ass</td>
<td>1</td>
<td>73.1050</td>
<td>73.1050</td>
<td>17.67</td>
<td>0.0001</td>
</tr>
<tr>
<td>Acc vs Con</td>
<td>1</td>
<td>21.3555</td>
<td>21.3555</td>
<td>5.16</td>
<td>0.0246</td>
</tr>
<tr>
<td>Acc vs Div</td>
<td>1</td>
<td>8.6180</td>
<td>8.6180</td>
<td>2.08</td>
<td>0.1512</td>
</tr>
<tr>
<td>Ass vs Con</td>
<td>1</td>
<td>12.5357</td>
<td>12.5357</td>
<td>3.03</td>
<td>0.0840</td>
</tr>
<tr>
<td>Ass vs Div</td>
<td>1</td>
<td>19.8977</td>
<td>19.8977</td>
<td>4.81</td>
<td>0.0300</td>
</tr>
<tr>
<td>Con vs Div</td>
<td>1</td>
<td>1.6228</td>
<td>1.6228</td>
<td>0.39</td>
<td>0.5321</td>
</tr>
</tbody>
</table>

The comparison of means between presentation methods based upon each learning style is shown in Figure 4. Figure 5 shows the comparison of mean scores in knowledge acquisition among learning styles based upon each presentation method.
Figure 4. Comparison of Means (Class*Style)

Figure 5. Comparison of Means (Style*Class)
Main Effects

Because interaction effects between presentation methods and learning style were found and analyzed, main effects were considered not to be important in the analysis. However, main effects for each treatment were analyzed. Main effect for presentation methods was detected, $F(1, 144) = 14.12$, $p = 0.0003$. There was also a significant main effect for learning style, $F(3, 142) = 5.93$, $p = 0.0008$, when learning style was considered in conjunction with other predictors in the model. Because a significant $F$ Value was found in the omnibus test for learning style, post hoc multiple comparison tests were conducted with the SAS GLM procedure to find significant differences between each learning style. The results, as seen in Table 8, show several significant differences in the performance scores on knowledge acquisition in the comparison between assimilator and accommodator ($p = 0.0043$), comparison between assimilator and diverger ($p = 0.0003$), comparison between converger and accommodator ($p = 0.0481$), and comparison between converger and diverger ($p = 0.0062$) at the 0.05 level of significance.

Table 8

<table>
<thead>
<tr>
<th>Learning Style Comparison</th>
<th>DF</th>
<th>Contrast SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assimilator - Converger</td>
<td>1</td>
<td>2.6376</td>
<td>2.6376</td>
<td>0.64</td>
<td>0.4260</td>
</tr>
<tr>
<td>Assimilator - Accommodator</td>
<td>1</td>
<td>34.8774</td>
<td>34.8774</td>
<td>8.43</td>
<td>0.0043</td>
</tr>
<tr>
<td>Assimilator - Diverger</td>
<td>1</td>
<td>56.0582</td>
<td>56.0582</td>
<td>13.55</td>
<td>0.0003</td>
</tr>
<tr>
<td>Converger - Accommodator</td>
<td>1</td>
<td>16.4573</td>
<td>16.4573</td>
<td>3.98</td>
<td>0.0481</td>
</tr>
<tr>
<td>Converger - Diverger</td>
<td>1</td>
<td>31.9818</td>
<td>31.9818</td>
<td>7.73</td>
<td>0.0062</td>
</tr>
<tr>
<td>Diverger - Accommodator</td>
<td>1</td>
<td>3.0772</td>
<td>3.0772</td>
<td>0.74</td>
<td>0.3899</td>
</tr>
</tbody>
</table>
Those results of main effects can be illustrated by the following figures. Figure 6 shows comparison of means between the traditional presentation and the computer-based presentation. Figure 7 presents comparison of means among each learning style.

**Figure 6.** Comparison of Mean Score (Class)

**Figure 7.** Comparison of Mean Score (Style)
Strength of Association

As shown in Table 4, a significant $F$ statistic indicates that some relationship existed between the dependent variable (knowledge acquisition) and the independent variables (presentation methods and learning style). Although this information was useful, it does not provide information about the strength of association between the dependent variable and the independent variables. Kirk (1995) suggests the most popular measures of strength of association, omega squared ($\omega^2$), for fixed treatment effects. Each strength of association is calculated as following:

$$\omega^2_{\text{Score} \cdot \text{Style} \cdot \text{Class}} = \frac{(q - 1)(F_{\text{Style}} - 1)}{(q - 1)(F_{\text{Style}} - 1) + N}$$

$$= \frac{(4 - 1)(5.93 - 1)}{(4 - 1)(5.93 - 1) + 146} = \frac{14.79}{160.79} = 0.09$$

$$\omega^2_{\text{Score} \cdot \text{Class} \cdot \text{Style}} = \frac{(p - 1)(q - 1)(F_{\text{Class} \cdot \text{Style}} - 1)}{(p - 1)(q - 1)(F_{\text{Class} \cdot \text{Style}} - 1) + N}$$

$$= \frac{(2 - 1)(4 - 1)(3.29 - 1)}{(2 - 1)(4 - 1)(3.29 - 1) + 146} = \frac{6.87}{152.87} = 0.04$$

$$\omega^2_{\text{Score} \cdot \text{Class} \cdot \text{Style}} = \frac{(p - 1)(F_{\text{Class}} - 1)}{(p - 1)(F_{\text{Class}} - 1) + N}$$

$$= \frac{(2 - 1)(14.12 - 1)}{(2 - 1)(14.12 - 1) + 146} = \frac{13.12}{159.12} = 0.08$$
According to Cohen's (1988) guidelines, there is a medium association between knowledge acquisition and (1) learning style and (2) presentation methods, learning style interaction because the omega squared, 0.08, is greater than 0.06. Also, the association between knowledge acquisition and (1) presentation methods and (2) presentation methods, learning style interaction indicates a medium association because of the omega squared, 0.09. But, the association between knowledge acquisition and (1) presentation methods and (2) learning style shows a small association because of the small omega squared, 0.04.

**Power Analysis**

The power of the treatment effects test was analyzed using a SAS Macro written by Latour (1991). The results are shown in Table 9.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Effect Size</th>
<th>Power of Test</th>
<th>Confidence Interval: Lower Limit</th>
<th>Confidence Interval: Upper Limit</th>
<th>Least Significant Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>0.5166</td>
<td>0.86291</td>
<td>0.19178</td>
<td>0.99886</td>
<td>63</td>
</tr>
<tr>
<td>Style</td>
<td>0.7850</td>
<td>0.98173</td>
<td>0.29712</td>
<td>1.00000</td>
<td>57</td>
</tr>
<tr>
<td>Class*Style</td>
<td>0.5287</td>
<td>0.74331</td>
<td>0.05557</td>
<td>0.99957</td>
<td>119</td>
</tr>
</tbody>
</table>

*(Note. Type I Error Rate = 0.05, Sample Size = 146)*

As shown in Table 9, power of test explains the probability of the statistical analysis to find significance, if in fact, significance is there. Because the power of a test for presentation methods (Class) is 0.86191, 86 times out of 100 the statistical procedures will be capable of detecting the significant difference between traditional presentation
and computer-based presentation (H1). The power of a test for learning style (Style) explains the probability of rejecting a false complete null hypothesis, H2, is 98 percent. If the interaction effects exist, the probability of rejecting the null hypothesis for interaction effects, H3, is 74 percent.

Hypotheses Testing

Based upon the results in the previous statistical analysis, hypotheses stated in Chapter III were tested. The hypotheses were stated in terms of the relationships between presentation methods and knowledge acquisition, learning style and knowledge acquisition, and the interaction effect of presentation methods and learning style on knowledge acquisition.

**H1: There is no significant difference in knowledge acquisition between the traditional presentation and computer-based presentation.** This hypothesis was proposed to test whether students would vary in knowledge acquisition when faced with different types of presentation methods. Based upon the data collected and analyzed, H1 was rejected (Table 5) at a significance level of 0.05, $F(1, 144) = 14.12, \ p = 0.0003$. This suggests that there was a significant difference in knowledge acquisition between the traditional presentation and computer-based presentation. Those students in the computer-based presentation scored significantly higher in knowledge acquisition than the students in the traditional presentation, as illustrated in Figure 6. However, this hypothesis should be considered with other treatment, learning style, because some interaction effects between presentation methods and learning style were found.
H2: There are no significant differences in knowledge acquisition among different types of learning styles. This hypothesis was proposed to test whether students' performance scores in the knowledge acquisition would vary with different learning styles. Based upon the data collected and analyzed, H2 was rejected (Table 5) at a significance level of 0.05, $F(3, 142) = 5.93, p = 0.0008$. This suggests that there were significant differences in knowledge acquisition across learning styles. Because a significant $F$ ratio was found in the main effects for learning style, post hoc multiple comparisons tests were conducted with the SAS GLM procedure. The results (Table 8) showed several significance in the performance scores on knowledge acquisition in the comparison between assimilator and accommodator ($p = 0.0043$), comparison between assimilator and diverger ($p = 0.0003$), comparison between converger and accommodator ($p = 0.0481$), and comparison between converger and diverger ($p = 0.0062$) at the 0.05 level of significance. This was illustrated in Figure 7.

This test was divided into six hypotheses based on different comparisons of learning styles:

H2a: There is no significant difference in knowledge acquisition between Assimilator and Converger.

H2b: There is no significant difference in knowledge acquisition between Assimilator and Accommodator.

H2c: There is no significant difference in knowledge acquisition between Assimilator and Diverger.

H2d: There is no significant difference in knowledge acquisition between Converger and Accommodator.
H2e: There is no significant difference in knowledge acquisition between Converger and Diverger.

H2f: There is no significant difference in knowledge acquisition between Accommodator and Diverger.

Based upon the post hoc multiple comparison test, as shown in Table 8, H2b was rejected at a significance level of 0.05. This suggests that there was a significant difference in knowledge acquisition between assimilator and accommodator. As shown in Figure 7, assimilator students had significantly higher performance scores in knowledge acquisition when compared to accommodator students. H2c was also rejected, indicating a significant difference in knowledge acquisition between assimilator and diverger. Assimilator students had significantly higher performance scores in knowledge acquisition when compared to diverger students, as illustrated in Figure 7. H2d was also rejected, indicating a significant difference in knowledge acquisition between converger and accommodator. Converger students had a significantly higher score in knowledge acquisition when compared to accommodator students, as illustrated in Figure 7. H2e was also rejected, indicating a significant difference in knowledge acquisition between converger and diverger. Converger students had a significantly higher score in knowledge acquisition when compared to diverger students, as illustrated in Figure 7. Two other hypotheses, H2a and H2f, were retained, which indicates the differences in knowledge acquisition between assimilator and converger, and between diverger and accommodator were not statistically significant. The results imply that assimilator students and converger students do not perform differently in the knowledge
acquisition although they have different learning styles. Also, diverger students and accommodator students did not perform much differently on knowledge acquisition.

**H2g:** There is no significant difference in knowledge acquisition between thinking-oriented students (Converger and Assimilator) and feeling-oriented students (Accommodator and Diverger).

**H2h:** There is no significant difference in knowledge acquisition between doing-oriented students (Accommodator and Converger) and watching-oriented students (Diverger and Assimilator).

As shown in Figure 1, The Cycle of Learning and Learning Style, the LSI measures how much each learner relies on four different learning modes that are part of a four-stage cycle of learning. Different learners have different emphasis on places in this cycle. Converger combines learning modes of doing and thinking. Diverger combines learning models of feeling and watching. Assimilator combines learning modes of thinking and watching. Accommodator combines learning modes of feeling and doing. Hypotheses H2g and H2h were developed based upon these two bipolar dimensions of cognitive domain: feeling-thinking dimension and doing-watching dimension.

Based upon the data collected and analyzed, H2g was rejected (Table 10) at a significance level of 0.05, $F(1, 144) = 17.20, p = 0.0001$. This suggests that there was a significant difference in knowledge acquisition between feeling-oriented students and thinking-oriented students. Thinking-oriented students scored significantly higher scores on knowledge acquisition when compared to feeling-oriented students, as illustrated in Figure 8. However, the result indicates there was no interaction between presentation methods and thinking-orientation or feeling-orientation.
Figure 8. Comparison of Mean Score between Thinking and Feeling

However, based upon the data collected and analyzed, H2h was retained (Table 11) at a significance level of 0.05, $F(1, 144) = 0.18$, $p = 0.6700$. This suggests that there was no significant difference in knowledge acquisition between doing-oriented students and watching-oriented students. Watching-oriented students did not score
significantly different on knowledge acquisition when compared to doing-oriented students, as illustrated in Figure 9. But, interesting results were found. There was significant interaction effect between presentation methods and doing-orientation or watching-orientation. For further analysis, simple main effects were analyzed by the GLM Regression analysis with contrast option. These results are shown in Table 12. It indicates that doing-oriented students had significant differences in knowledge acquisition between two different presentation methods. This data were plotted in Figure 10. It shows that doing-oriented students had a much higher score in knowledge acquisition in the computer-based presentation when compared to the traditional presentation.

Table 11

GLM Regression Analysis Summary (Action and Class)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>3</td>
<td>90.4382</td>
<td>30.1460</td>
<td>6.58</td>
<td>0.0003</td>
</tr>
<tr>
<td>Error</td>
<td>142</td>
<td>650.1918</td>
<td>4.5788</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>145</td>
<td>740.6301</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action (Doing or Watching)</td>
<td>1</td>
<td>0.8349</td>
<td>0.8349</td>
<td>0.18</td>
<td>0.6700</td>
</tr>
<tr>
<td>Class</td>
<td>1</td>
<td>48.0720</td>
<td>48.0720</td>
<td>10.50</td>
<td>0.0015</td>
</tr>
<tr>
<td>Action*Class</td>
<td>1</td>
<td>45.2421</td>
<td>45.2421</td>
<td>9.88</td>
<td>0.0020</td>
</tr>
</tbody>
</table>
Figure 9. Comparison of Mean Score between Doing and Watching

Table 12

Simple Main Effects Summary (Class and Action)

<table>
<thead>
<tr>
<th>Contrast</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class at Doing-Oriented</td>
<td>1</td>
<td>87.2145</td>
<td>87.2145</td>
<td>19.05</td>
<td>0.0001</td>
</tr>
<tr>
<td>Class at Watching-Oriented</td>
<td>1</td>
<td>0.0230</td>
<td>0.0230</td>
<td>0.01</td>
<td>0.9435</td>
</tr>
<tr>
<td>Action at Computer-Based</td>
<td>1</td>
<td>13.7818</td>
<td>13.7818</td>
<td>3.01</td>
<td>0.0849</td>
</tr>
<tr>
<td>Action at Traditional</td>
<td>1</td>
<td>37.6913</td>
<td>37.6913</td>
<td>8.23</td>
<td>0.0047</td>
</tr>
</tbody>
</table>
H3: There are no significant interactions between students with different types of learning styles and presentation methods in knowledge acquisition.

This hypothesis was proposed to test whether students’ knowledge acquisition would vary with interactions between different learning style and presentation methods. Based on data collected and analyzed, H3 was rejected (Table 5) at a significance level of 0.05, $F(3, 142) = 3.29$, $p = 0.0227$. This suggests that there were significant interactions in knowledge acquisition between learning style and presentation methods. These interaction effects were already analyzed and discussed in the previous section. The results of the previous all hypotheses are summarized in Table 13.
## Table 13

**Summary of Hypotheses Testing**

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Pr &gt; F</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: There is no significant difference in knowledge acquisition between the traditional presentation and computer-based presentation.</td>
<td>0.0003</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2. There are no significant differences in knowledge acquisition among different types of learning styles.</td>
<td>0.0008</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2a: There is no significant difference in knowledge acquisition between Assimilator and Converger.</td>
<td>0.4260</td>
<td>Accepted</td>
</tr>
<tr>
<td>H2b: There is no significant difference in knowledge acquisition between Assimilator and Accommodator.</td>
<td>0.0043</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2c: There is no significant difference in knowledge acquisition between Assimilator and Diverger.</td>
<td>0.0003</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2d: There is no significant difference in knowledge acquisition between Converger and Accommodator.</td>
<td>0.0481</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2e: There is no significant difference in knowledge acquisition between Converger and Diverger.</td>
<td>0.0062</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2f: There is no significant difference in knowledge acquisition between Accommodator and Diverger.</td>
<td>0.3899</td>
<td>Accepted</td>
</tr>
<tr>
<td>H2g: There is no significant difference in knowledge acquisition between thinking-oriented students (Converger and Assimilator) and feeling-oriented students (Accommodator and Diverger).</td>
<td>0.0001</td>
<td>Rejected</td>
</tr>
<tr>
<td>H2h: There is no significant difference in knowledge acquisition between doing-oriented students (Accommodator and Converger) and watching-oriented students (Diverger and Assimilator).</td>
<td>0.6700</td>
<td>Accepted</td>
</tr>
<tr>
<td>H3: There are no significant interactions between students with different types of learning styles and presentation methods in knowledge acquisition.</td>
<td>0.0227</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

*(Note. Based on a significance level of 0.05)*
CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to investigate the effects of four learning styles (accommodator, assimilator, converger, and diverger) and two presentation methods (computer-based presentation and traditional presentation) on knowledge acquisition. The overall hypothesis was that if instruction was presented in a format that matched the learning style of students, they would score higher on the performance measure. It was hypothesized that students would score differently on measures of knowledge acquisition when instruction was delivered in a format of a computer-based presentation compared to the traditional presentation format. It was also hypothesized that there were significant differences in performance levels on the knowledge acquisition across different learning styles. This chapter discusses the results of the study and offers some conclusions and interpretations. Some recommendations for instructional design and development are suggested, and recommendations for further research are presented.

Conclusions

In learning style of accommodator and converger, contrasts of the traditional presentation and computer-based presentation showed that knowledge acquisition scores of the students who received instruction in the computer-based presentation were significantly higher than the scores of the students who received instruction in the traditional presentation. This provides evidence that instructional technology facilitated
knowledge acquisition to some degree with students of the specific learning styles.

It was hypothesized that there were significant differences in knowledge acquisition among different types of learning style. According to the Scheffe's test, among six different contrasts, only two contrasts, assimilator-accommodator and assimilator-divergent, had significant differences in knowledge acquisition. These results suggest that learning style itself does not give many clues to measuring performance in knowledge acquisition. It can be said that learning style should be considered with some other attributes to determine the learning performance.

For the interaction, it was hypothesized that students would score higher on knowledge acquisition when their learning style was matched to the presentation format of instruction. Accommodator students and converger students had a much better performance in the computer-based presentation than in the traditional presentation. Thus, this study supported the baseline of aptitude treatment interaction (ATI) research, which were to determine whether the effects of different instructional methods were influenced by the cognitive or personality characteristics of the learner.

These results were not surprising. Even though some previous research show the conflicting views of the relationship of learning styles to instructional setting in the learning environment (Dunn, 1990; Kavale & Forness, 1987, 1990), many ATI researchers show the relationships of learning modes to training methods on the learning performance (Bostrom, Olfman, & Sein, 1990; Masten, 1989; Dunn, 1983; Riding, Buckle, Thompson, & Hagger, 1989; Federico, 1982). The results of this study supported
The significant relationships of learning modes to training methods on the learning performance.

The color effects on the learning performance were shown in the previous research (Hoadley, 1990; Gruillion & Jenkins, 1981; Benbasat, Dexter, & Todd, 1986). The major findings from the literature are that multicolor improves performance in a recall task, color improves performance in a search-and-locate task, and color improves performance in a retention task. According to Hoadley (1990), color also improves comprehension of instructional materials and improves performance in a decision judgement task. In this study, the traditional presentation used black on clear transparencies to deliver instruction. On the other hand, the computer-based presentation utilized a multicolor presentation software, MS PowerPoint. The computer-based presentation with multicolor was expected to produce a higher performance in knowledge acquisition compared to the traditional presentation with black on clear transparencies. The results of this study can be partially explained by color effects.

Also, in the computer-based presentation classroom, all desktop computers were connected with a network, which enables each student access into the Internet. During the instruction, students were allowed to practice some applications in the Internet. It was expected that instructional technology enhances knowledge acquisition. The content of instruction delivered to students involved instructional technology, which was directly related to the classroom setting. The Internet is one of the hottest information technologies in our society at this time. Classroom setting with instructional technology is necessary to exercise the Internet application. Hence, it was believed that the
computer-based presentation would enhance knowledge acquisition of this subject. The results of this study supported this expectation.

Although the results of this study showed significant interaction effects between presentation methods and learning style of students on knowledge acquisition, strength of the association between knowledge acquisition and (1) presentation methods and (2) learning style shows a small association ($\omega^2 = 0.04$). Also as shown in Table 8, power of test for interaction was 74 percent, which was smaller than any other variables. Hence, there appears to be some other factors that may have influenced these results. They can be a small sample size, a weakness in the instructional design, or shortcomings in the Kolb's LSI-1985.

Some previous researchers have expressed general concern about aptitude treatment interaction (ATI) research (Cronbach, 1975; Tobias, 1982). In particular, Tobia (1982) has expressed the view that prior knowledge of subject matter may be a confounding factor of such experiments. This study may have the same concern, but prior knowledge levels about the Internet were assumed to be the same across all subjects. The motivation level of subjects may also be a potential confounding factor. Except for acquiring new knowledge about the Internet, participants did not have any benefits from this study. Hence, it could generate a low motivation in the participation.

In the consideration of experimental design, the number of subjects in the cells was small, ranging from 12 to 42. In only one cell, the number of subjects was 42, and all other cell size was equal to or less than 20. But those cell sizes were enough to satisfy the minimum requirement for the experiment.
Finally, one other point to be mentioned is learning style measurement. Even though there are considerable supports for Kolb's LSI-1985 (Hickcox, 1995; Sewall, 1986), some questions still remained regarding reliability and validity of the instrument (Ruble & Stout, 1993; Atkinson, 1991). However, it is generally accepted that sufficient evidence exists to support the theoretical assumptions and that Kolb's LSI is very useful, especially for pedagogical purposes (Bostrom, Olfman, & Sein, 1990).

Recommendations for Instructional Design and Development

Several recommendations can be suggested based upon the results of this study from two different perspectives: instructional technology and learning style. Instructional technology is growing more rapidly with new technology. This study strongly supports the use of instructional technology in the classroom in the specific learning styles, accommodator and converger. Thus, it is recommended that educational institutions invest in their instructional technology so that faculties can be prepared to utilize technology effectively in the classroom with specific learning styles. Instructional designers need to consider the benefits of instructional technology. Technology is not a panacea for improving effectiveness and efficiency of learning. However, technology can provide the effective application in the learning environment.

The outcome of this study supports the need for matching instructional methods with individual differences in learning style. However, the learning style measurement should be repeatedly validated and tested for reliability before being used with the specific content of subject to be delivered and instructional treatments. A consistent pattern of findings indicates that learning style is an important predictor of learning
performance, both by itself and in interaction with any instructional treatments. The results suggest that in the instructional design process, it is important to match training methods to individual difference variables.

**Recommendations for Future Research**

Based upon the results of this study, several recommendations are suggested for future research in the area of learning style, instructional technology, instructional design, and classroom environments. First, a more reliable and validated learning style measurement needs to be developed. Kolb's LSI-1985 used in this study still needs to be validated and tested for its generalization. Other instruments, such as LSQ, MBTI, GEFT, and so on, developed for identifying individual difference need to be applied and tested. Developing a consistent indicator of individual difference should be one of the goals of future researchers.

Second, this study examined the effects of learning style and presentation methods on knowledge acquisition. Many other factors, such as task type, task variety, other cognitive styles or personality, and attitudes, need to be investigated. In terms of presentation methods, this study has investigated only two different presentation methods: the traditional presentation and the computer-based presentation. However, there will be many other ways to present information such as illustrated instruction, technical demonstration, or role playing. Further research may expand the experiment domain to address other methods in which to present new information.

Third, this study may be replicated with some other subject content area to give more powerful evidence of the results of this study. The subject content, an "Introduction
to the Internet,” delivered in this study was limited to the knowledge level of the
cognitive domain. The subject content can be expanded to any other level of cognitive
domain such as comprehension, application, analysis, synthesis, and evaluation.

Fourth, current instructional technology is widespread, but the empirical evidence
is not enough to support implementation of technology in educational institutions. This
study has investigated the learning effects of a computer-based presentation, but some
other electronically mediated learning technology, such as electronic classrooms,
electronic dormitory, education video access, computer access to resources, distance
learning, or computer conferencing, should be studied empirically.

Fifth, although this experiment involved 156 subjects, a larger, more diverse
sample would provide greater generalizability to the results of this study. Further, if
research time is not a constraint and a classroom for experiment is allowed, a verbal
protocol analysis could be used as a supplement to strengthen the results of this study.

Finally, in this study the time span between treatment and performance testing
was very short, which means it was based on the short-term memory. However, learning
and retention of information over long periods of time is more important in training,
education, and development. Future research should consider the performance test based
upon the long-term memory.
APPENDIX A

INFORMED CONSENT FORM
INFORMED CONSENT FORM

Title of investigation: An experimental Investigation on the Effects of Learning Style and Presentation Methods in Knowledge Acquisition in a University Classroom Environment

Principle Investigator: Youngtae Ryu

This is to certify that I, ______________________, hereby agree to participate as a volunteer in a study as authorized part of the education and research program of University of North Texas under the supervision of Youngtae Ryu.

An explanation of the study has been described to me that explains the procedures to be followed and the expected benefits. I have had an opportunity to ask questions about my participation, and all questions and inquiries have been answered to my satisfaction.

I have been assured that any information received in this study will remain anonymous and confidential.

I understand that I am free to withdraw my consent and to discontinue participation in the project at any time without penalty, prejudice, or loss of benefits.

This research study has been reviewed and approved by the Institutional Review Board for the protection of Human Subjects in Research, University of North Texas. For research related problems or questions regarding subjects' rights, the Institutional Review Board may be contacted through Mr. Mark Elder, Chairman, IRB, (817)565-3940.

I have read and understand the explanation provided to me and voluntarily agree to participate in this study.

_________________________________________  __________________________
Signature of Subject                              Date

_________________________________________
Principle Investigator

For further information, contact:
Youngtae Ryu (Youngtae@jove.acs.unt.edu)
3400 Joyce Lane #276
Denton, TX 76207
(Telephone: 817-566-5276)
Mr. Youngtae Ryu  
3400 Joyce Lane #276  
Denton, TX 76207  

Re: Human Subjects Application No. 96-164

Dear Mr. Ryu:

As permitted by federal law and regulations governing the use of human subjects in research projects (45 CFR 46), I have conducted an expedited review of your proposed project titled “An Experimental Investigation on the Effects of Learning Style and Presentation Methods in Knowledge Acquisition in a University Classroom Environment.” The risks inherent in this research are minimal, and the potential benefits to the subjects outweigh those risks. The submitted protocol and informed consent form are hereby approved for the use of human subjects on this project.

If the use of human subjects extends beyond 12 months from this date, U.S. Department of Health and Human Services regulations require that the project be re-reviewed yearly. In such a case, please submit annual progress reports to the UNT Institutional Review Board. Further, the UNT IRB must re-review this project prior to any modifications you make in the approved project. Please contact me if you wish to make such changes or need additional information.

If you have questions, please contact me.

Sincerely,

Mark Elder  
Chairman  
Institutional Review Board

cc. IRB Members
APPENDIX B

LEARNING STYLE MEASUREMENT
June 18, 1996

Dear Tamara Friedman:

This is Youngtae Ryu, a Ph.D. student in University of North Texas. I am doing a research for my doctoral dissertation. I'd like to use the Learning Style Inventory in my research. So, I have already placed an order for those materials by phone.

In addition to this, I'd like to include a copy of the instrument in my dissertation. This is a reason that I'm writing a letter. The purpose of my research is to investigate the effects of learning style and presentation methods in knowledge acquisition. Specifically, the research is an in-depth experimental investigation of effects of learning style and presentation methods in knowledge acquisition in an university environment to increase the effectiveness of instructional delivery.

The proposed research title is “An Experimental Investigation on the Effects of Learning Style and Presentation Methods in Knowledge Acquisition in a University Classroom Environment.” If you have any questions regarding this request, please contact me at 817-566-5276. Thank you,

Sincerely,

Youngtae Ryu
Applied Technology, Training, and Development
University of North Texas
Denton, Texas
June 24, 1996

Hay McBer

Youngtae Ryu
3400 Joyce Lane #276
Denton, TX 76207

Dear Youngtae:

Yes, you may have permission to reproduce the Learning Style Inventory test and graphs for the appendix of your dissertation. Please reference our copyright notation on all reproduced pages.


We do not allow the LSI to be 'microfiched', however. If your dissertation is put on microfilm, please replace the LSI with a page referencing our name, address and phone number so they may contact us. If you have any other questions, please contact us at, 800-729-8074. Thank you.

Sincerely,

Tamara Friedman
Training Resources Group
McBer & Company

Name: __________________________

Position: ________________________

Organization: ____________________

Date: ____________________________

Inventory
Learning-Style Inventory: Instructions

The Learning-Style Inventory describes the way you learn and how you deal with ideas and day-to-day situations in your life. Below are 12 sentences with a choice of four endings. Rank the endings for each sentence according to how well you think each one fits with how you would go about learning something. Try to recall some recent situations where you had to learn something new, perhaps in your job. Then, using the spaces provided, rank a “4” for the sentence ending that describes how you learn best, down to a “1” for the sentence ending that seems least like the way you would learn. Be sure to rank all the endings for each sentence unit. Please do not make ties.

Example of completed sentence set:

When I learn:  
1 like to deal with my feelings  
/  I like to watch and listen  
/  I like to think about ideas  
/  I like to be doing things

1. When I learn:  
/  I like to deal with my feelings  
/  I like to watch and listen  
/  I like to think about ideas  
/  I like to be doing things

2. I learn best when:  
/  I trust my hunches and feelings  
/  I listen and watch carefully  
/  I rely on logical thinking  
/  I work hard to get things done

3. When I am learning:  
/  I have strong feelings and reactions  
/  I am quiet and reserved  
/  I tend to reason things out  
/  I am responsible about things

4. I learn by:  
/  feeling  
/  watching  
/  thinking  
/  doing

5. When I learn:  
/  I am open to new experiences  
/  I look at all sides of issues  
/  I like to analyze things, break them down into their parts  
/  I like to try things out

6. When I am learning:  
/  I am an intuitive person  
/  I am an observing person  
/  I am a logical person  
/  I am an active person

7. I learn best from:  
/  personal relationships  
/  observation  
/  rational theories  
/  a chance to try out and practice

8. When I learn:  
/  I feel personally involved in things  
/  I take my time before acting  
/  I like ideas and theories  
/  I like to see results from my work

9. I learn best when:  
/  I rely on my feelings  
/  I rely on my observations  
/  I rely on my ideas  
/  I can try things out for myself

10. When I am learning:  
/  I am an accepting person  
/  I am a reserved person  
/  I am a rational person  
/  I am a responsible person

11. When I learn:  
/  I get involved  
/  I like to observe  
/  I evaluate things  
/  I like to be active

12. I learn best when:  
/  I am receptive and open-minded  
/  I am careful  
/  I analyze ideas  
/  I am practical

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MCB200
Learning-Style Type Grid

Accommodator

Diverger

Converger

Assimilator

Percentiles 0

Published by McBer & Company.
APPENDIX C

INSTRUCTIONAL MATERIAL
Introduction to the Internet

This course covers the use of various campus-wide information systems with emphasis on the Internet including the World-Wide Web and Electronic Mail. The purpose of this seminar is to provide a conceptual background for using the Internet. Emphasis is on the basic knowledge of Internet tools, proper use of these tools, and tips on getting more information about the Internet itself.

What is the Internet?

The Internet is a network of interconnected computers that share information and data. The Internet consists of a worldwide “network of networks” with common protocols (rules) for supporting the transfer of electronic information between them. The Internet is made up of regional networks, commercial networks, corporate networks, and government networks scattered throughout the globe all interconnected by high-speed digital circuits. Any site (often referred to as a “host”) connected to one of these networks is an “Internet site.”

Figure 1. Internet Connectivity map
Why use the Internet?

The Internet provides many services, including electronic mail, file transfer, remote login, access to Usenet, etc. The Internet gives us high-speed global connectivity at no cost. Some of the services include:

- Electronic Mail
- Subject-oriented discussion groups (USENET news)
- Remote access (telnet)
- File transfer protocol (ftp)
- Gopher
- World Wide Web (WWW)

How does the Internet work?

When trying to understand how the Internet sends information from one computer to another, think of how the U.S. Postal Service operates. When a letter is sent, it is mixed with everyone else’s letters, put on trucks or airplanes, transferred to another post office, and sorted out again before delivery to the address posted.

Internet Protocol addresses (IP addresses)

The Internet includes many different types of networks including Ethernet, token rings, and telephone lines. Think of Ethernet and telephone lines as equivalent to the trucks and airplanes of the U.S. Postal Service. They provide a means by which mail is moved from place to place. Think of routers as postal substations; they decide how to route data, just like a postal substation decides how to “route” mail. Each router or substation does not have a connection to every other one. The local post office sends a mail to a substation; the substation sends it to another substation; and so on until it reaches its destination. Similarly, with the Internet, a router looks at where data is going
and decides where to send it next.

How does the Internet know where your data is going? If you want to send a letter, you cannot just drop a letter in a mailbox and expect it to get delivered. You need to put the letter in an envelope, write an address on it, and stick a stamp on it. Just as the post office has rules, the Internet has rules for its use. These rules are called protocols. The Internet Protocol (IP) takes care of addressing, or making sure that the routers know what to do with your data when it arrives. Keeping with the post office analogy, the Internet Protocol works just like an envelope.

**The Transmission Control Protocol (TCP)**

TCP is another rule which the Internet uses to transmit and receive information. TCP is the protocol, often mentioned with IP. To describe what the TCP does, consider what would happen if we want to send a book to someone, but the post office only accept letters? We could tear each page out of the book, put each page in a separate envelope, and mail them separately. The recipient would then have to make sure all the pages arrived and paste them back together in the right order. This is what TCP does.

TCP takes the data that we send and breaks it into pieces. It numbers each piece so that the data can be put back in the right order upon arrival. In order for the Internet to pass this sequence number across the network, the Internet has an envelope which has the information it requires “written on it.” A piece of data is placed inside a TCP envelope. The TCP envelope is then placed inside an IP envelope and given to the network. Once we have something in an IP envelope, the network can carry it.
On the receiving end, a TCP software package collects the envelopes, removes the data, and puts it into the proper order. If any data is missing, TCP asks the sender to resend them. When TCP has all the information in the correct order, it passes the data to whatever application program is being used.

**Internet addressing**

Before we can start using all of the resources on the Internet, we must become familiar with the Internet style addressing. An Internet style E-mail address will have three main sections:

User-Id@Hostname.Domain (youngtae@jove.acs.unt.edu)

These sections can be broken down as follows:

- **User-Id**: An address representing a personal account on a host computer (youngtae).
- **Hostname**: The name of a computer system on which we can hold an interactive session, or which provides network services (jove).
- **Domain**: A structured name for a computer in a network, with each section separated by a period. The hierarchy of naming ensures that each name is unique (acs.unt.edu).

All three sections together make up an Internet style E-mail address. The sections to the right of the "@" symbol comprise the **Internet name** for a host computer. When both the host name and the domain name are specified, the sections to the right of the "@" symbol are also called a Fully Qualified Domain Name or a Fully Qualified Host Name.

**Who pays for the Internet?**

No one pays for the whole Internet; there is no Internet, Inc. that collects fees from all Internet networks or users. Instead, everyone pays their part of the Internet. Networks
get together and decide how to connect themselves together and fund these interconnections. A college or corporation pays for their connection to some regional network, which in turns pays a national provider for its access.

**Electronic Mail**

Electronic mail, known as E-mail, allows us to communicate quickly and easily with colleagues on campus or around the world. Since most people can easily relate to the concept of sending and receiving mail, this service is one of the easiest to use. The use of E-mail is rapidly increasing and changing our communication in almost every area of our lives. Examples of E-mail program are Pine, Pegasus, WordPerfect Office, and GroupWise.

**Uses:**

- Correspondence with friends, family, peers, experts in the field, representatives of institutions, organizations, and governments, etc.

- Keeping abreast of subject-oriented information through subscribing to mail lists (LISTSERV).

A mailing list distributes electronic mail to interest groups. You must “subscribe” electronically to a mailing list to receive mail from that list. When a subscriber has a question, or just wants to say something of general interest to members of the mailing list, he or she sends a message to a central address, which forwards his/her message to all of the mailing list members, all within a few minutes.

Examples: Pine, Pegasus, WordPerfect Office, GroupWise
USENET News

USENET News can be thought of as a world-wide Bulletin Board System (BBS). A BBS provides a computerized discussion forum. On USENET, these discussions range from politics to recipes. The discussions on USENET provide a powerful forum in which to ask questions, get opinions, get answers, and conduct research.

USENET is broken down into several thousand conferences called newsgroups. Each newsgroup has a hierarchical name such as “unt.class.spring96.psci.4450-001”. Often, a mailing list also appears as a USENET newsgroup (sometimes under a different name). Usually, it is recommended to use the USENET newsgroup because we conserve disk space and we do not need to subscribe as compared to the LISTSERV.

Examples of USENET News program are tin, nn_beta, and TRUMPET.

Remote Access (TELNET)

Telnet and TN3270 are called remote access terminal protocols. These programs allow you to login into a remote computer system on the Internet as though your terminal is directly hooked up to it. In general, you must have an account on the remote host.

To access a remote host using either Telnet or TN3270 you need the following:

- Internet name or address of a remote host (ex., jove.acs.unt.edu)
- A user account on the remote host
- A local host on the Internet

Telnet will emulate a VT100 terminal except on CMS (where it will emulate a 3270 terminal). TN3270 will emulate a 3270 terminal for access to IBM mainframe.
File Transfer Protocol (FTP)

File Transfer Protocol, or ftp, is used to accomplish high-speed file transfers between two computers on the Internet. You can transfer files between two computers on which you have accounts, or you can copy files from public access ftp sites using anonymous ftp.

There is a special “anonymous” User-ID for FTP users available on some hosts. If a host supports this special User-ID, the host is said to support “Anonymous FTP.” If you wish to transfer files to or from a host computer on which you do not have a regular account, enter anonymous as your User-ID and enter your E-mail address (ex, youngtae@unt.edu) as the password. You are then logged in to a special account called “FTP” with a different home directory and subset of available commands.

Gopher

Gopher provides a very unique window into the Internet. It offers browsing and an easy way to access information found on the Internet. Gopher was originally designed to be a text retrieval tool, but now it supports more multi-media formats (Gopher+).

To use Gopher, you either need to obtain a Gopher client program or you can use a public Gopher site via Telnet. You can use your Gopher client to access any number of Gopher information servers around the world. The Gopher server at the University of Minnesota is the original server and collectively all servers are called "Gopherspace".

Once you are logged onto a Gopher server, you can use the menus to traverse to information for which you are looking. These menus may contain item selections that are found on other computers. Most of the connections and remote accessing will be handled
by the Gopher client and you only have to worry about selecting what you want. Gopher allows you to search for items, open another Gopher server, and locate information.

**World-Wide Web (WWW)**

The **World-Wide Web** can be described as a "wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents".

What the World-Wide Web (WWW, W3) project has done to provide users on computer networks with a consistent means to access a variety of media in a simplified fashion.

Using a popular software interface to the Web called **Netscape** or **Microsoft Internet Explorer**, the Web project has changed the way people view and create information.

![Image of World-Wide Web Browser Elements](image)

**Figure 2.** Elements of World-Wide Web Browser

The World-Wide Web uses the Internet to transmit hypermedia documents between computer users internationally. Much in the same way, nobody "owns" the World-Wide Web. People are responsible for the documents they author and make available publicly on the Web. Via the Internet, hundreds of thousands of people around the world are making information available from their homes, schools, and workplaces.
Hypertext and Hypermedia

The operation of the Web relies mainly upon hypertext as its means of interacting with users. Hypertext is basically the same as regular text - it can be stored, read, searched, or edited - with an important exception: hypertext contains connections, called hyperlinks, within the text to other documents.

![Diagram of hypertext and hypermedia]

**Figure 3. Hypertext and Hypermedia**

Hypermedia is hypertext with a difference - hypermedia documents contain links not only to other pieces of text, but also to the other forms of media - sounds, images, and movies. Images themselves can be selected to link to sounds or documents. Hypermedia simply combines hypertext and multimedia.

Web client and Web server

Web software is designed around a distributed client-server architecture. A Web client (called a Web browser if it is intended for interactive use) is a program which can send requests for documents to any Web server. A Web server is a program that, upon
receipt of a request, sends the document requested (or an error message if appropriate) back to the requesting client. Using a distributed architecture means that a client program may be running on a completely separate machine from that of the server, possibly in another room or even in another country. Because the task of document storage is left to the server and the task of document presentation is left to the client, each program can concentrate on those duties and progress independently of each other.

Figure 4, Web Client and Web Server

Hypertext Transfer Protocol (HTTP)

The language that Web clients and servers use to communicate with each other is called the Hypertext Transfer Protocol (HTTP). All Web clients and servers must be able to speak HTTP in order to send and receive hypermedia documents. For this reason, Web servers are often called HTTP servers.
The phrase “World-Wide Web” is often used to refer to the collective network of servers speaking HTTP as well as the global body of information available using protocol.

**Hypertext Markup Language (HTML)**

The standard language the Web uses for creating and recognizing hypermedia documents is the Hypertext Markup Language (HTML). It is loosely related to, but technically not a subset of, the Standard Generalized Markup Language (SGML), a method of representing document formatting languages. Languages such as HTML which follow the SGML format allow document writers to separate information from document presentation - that is, documents containing the same information can be presented in a number of different ways. Users have the option of controlling visual elements such as fonts, font size, and paragraph spacing without changing the original information.

HTML is widely praised for its ease of use. Web documents are typically written in HTML and are usually named with the suffix “.html”. HTML documents are nothing more than standard text files with formatting codes that contain information about layout (text styles, document titles, paragraphs, lists) and hyperlinks.

![Figure 5. Hypertext Markup Language (HTML)](image-url)
Uniform Resource Locators (URLs)

The World-Wide Web uses what are called Uniform Resource Locators (URLs) to represent hypermedia links and links to network services within HTML documents. It is possible to represent nearly any file or service on the Internet with a URL.

Example: http://www.unt.edu/

The first part of the URL (before the two slashes) specifies the method of access such as http, gopher, ftp, telnet, mail, or news. The second part is typically the address of the computer where the data or service is located. Further parts may specify the names of files, the port to which to connect, or the text for which to search in a database. A URL is always a single unbroken line with no spaces.

How can I get more information?

Most of this information is available on the Internet. In order to access resources specified by a URL, you may need to use a Web browser that provides a public-access. Enter the URL as one unbroken line without spaces or carriage returns.

General Web Information

Main Netscape home page
http://home.netscape.com/

Main CERN World-Wide Web page
http://www.w3.org/hypertext/WWW/TheProject.html

Main NCSA Mosaic page
http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/NCSAMosaicHome.html

Information on WWW

Information on HTML and HTTP

How to write HTML
http://www.ncsa.uiuc.edu/General/Internet/WWW/HTMLPrimer.html

HTML Tutorials
http://curia.ucc.ie/info/net/htmldoc.html

HTML Style Guides
http://www.cs.cmu.edu/~tilt/cgh/
http://bookweb.cwis.uci.edu:8042/Staff/StyleGuide.html
http://www.w3.org/hypertext/WWW/Provider/Style/Overview.html

HTML Quick Reference
http://www.cc.ukans.edu/info/HTML_quick.html

Web Search Engines (Exploring the Net)

General
http://altavista.digital.com/
APPENDIX D

BLACK ON CLEAR TRANSPARENCIES
Introduction to the Internet

Spring 1997

Objectives

- Get conceptual backgrounds of the Internet
- Customize various Internet tools
- Take more detailed knowledge about the World-Wide Web

Overviews

- Introduction (Conceptual Background)
- Tools
  - Electronic Mail (E-Mail)
  - USENET News
  - Remote Access (TELNET)
  - File Transfer Protocol (FTP)
  - Gopher
  - World-Wide Web (WWW)
Introduction to the Internet

What is the Internet?

- The word "internet" literally means "network of networks."
- In itself, the Internet is comprised of thousands of smaller regional networks scattered throughout the globe.

University of North Texas
Applied Technology, Training, and Development

Introduction to the Internet

What is the Internet?

University of North Texas
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Introduction to the Internet

Timeline (Hosts)

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Introduction to the Internet

Why use the Internet?

The Internet provides many services:
- Electronic mail
- Subject-oriented discussion groups
- Remote access
- File transfer
- Gopher
- Word-Wide Web

How it works?

- Protocols
  - Internet Protocol (IP)
  - Transmission Control Protocol (TCP)
- Internet addressing
  - User-id @ Hostname.Domain (youngtae@unt.edu)
Introduction to the Internet

Electronic Mail

• Example:
  - Pine
  - Pegasus
  - WordPerfect Office
  - GroupWrite
• Listserv

Introduction to the Internet

USENET News

• Electronic Bulletin Board System (BBS)
• Computerized Discussion Forum
• No Subscription
• Compared with Listserv

Introduction to the Internet

Remote Access

• Access a remote computer system
• Internet address of a remote host
• User account on the remote host
• Local host on the Internet
Introduction to the Internet

File Transfer Protocol

- High-speed file transfers
- Anonymous FTP
  - User-ID: Anonymous
  - Password: E-mail address
- Log in to a special account called “FTP”

Gopher

- Text retrieval tool originally
- University of Minnesota
- Gopher Client
- Gopher Server (Gopherspace)

World-Wide Web

- Web Browser (MS IE. Netscape)
- Components of a web browser
  - Uniform Resource Locator (URL)
    - http://www.unt.edu/
  - Menu Bar
  - HyperText and Hyperlink
  - Scroll Bar
  - Inline Image
- Client/Server Computing
Introduction to the Internet

World-Wide Web

- Other services provided by a web browser:
  - Gopher (gopher://gopher.unt.edu)
  - Ftp (ftp://ftp.unt.edu)
  - Telnet (telnet://jove.acs.unt.edu)
  - Mail (mailto://)
  - Usenet News (news://)

- WWW supports all Internet services

---

Introduction to the Internet

Hypertext and Hypermedia

- Hyperlink
- Hypertext (text)
- Hypermedia (text, sounds, images, and movies)

---

Introduction to the Internet

Web Client and Web Server

- Hypertext Transfer Protocol (HTTP)
- Hypertext Markup Language (HTML)
Introduction to the Internet

General Web Information

- http://home.netscape.com/
- http://www.microsoft.com/
- http://www.utexas.edu/tutorial/default.html

Introduction to the Internet

Summary

- Conceptual Backgrounds
- Tools
  - USENET News
  - Remote Access (TELNET)
  - Electronic Mail (E-Mail)
  - File Transfer Protocol (FTP)
  - Gopher
  - World-Wide Web (WWW)
APPENDIX E

COMPUTER SLIDE SHOW
Get conceptual backgrounds of the Internet
Customize various Internet tools
Take more detailed knowledge about the World-Wide Web

Introduction (Conceptual Background):
Tools:
- Electronic Mail (E-Mail)
- USENET News
- Remote-Access (TELNET)
- File Transfer Protocol (FTP)
- Gopher
World-Wide Web (WWW)
The word "Internet" literally means "network of networks.
In itself, the Internet is comprised of thousands of smaller regional networks scattered throughout the globe.
The Internet provides many services:
Electronic mail
Subject-oriented discussion groups
Remote access
File transfer
Gopher
World-Wide Web
Example:
- Pine
- Procomm
- WordPerfect Office
- GroupWise
- Listserv

Electronic Bulletin Board System (BBS)
Computerized Discussion Forum
No Subscription
Compared with Listserv

Access a remote computer system
Internet address of a remote host
User account on the remote host
Local host on the Internet
Text retrieval tool originally University of Minnesota
Gopher Client
Gopher Server (Gopherspace)

High-speed file transfers
Anonymous FTP
- User-ID: Anonymous
- Password: E-mail address
- Log in to a special account called "FTP"

Web Browser (MS IE, Netscape)
Components of a web browser:
- Uniform Resource Locator (URL)
  http://www.umn.edu
- Menu Bar
- Hyperext and Hyperlink
- Scroll Bars
- Inline Image
- Client/Server Computing
Other services provided by a web browser:
- Gopher (gopher://gopher.unt.edu/)
- File (ftp://ftp.unt.edu/)
- Telnet (telnet://jove.acs.unt.edu/)
- Mail (mailto://)
- Usenet News (news://)
WWW supports all Internet services:

Hyperlink
Hypertext (text)
Hypermedia (text, sounds, images, and movies)
Conceptual Backgrounds

Tools
- USENET News
- Remote Access (TELNET)
- Electronic Mail (E-Mail)
- File Transfer Protocol (FTP)
- Gopher
- World-Wide Web (WWW)
APPENDIX F

TEST MATERIAL
Post-Test: Introduction to the Internet

Directions: Read carefully each question, select the best answer, and mark the correct number on the answer sheet provided with a #2 pencil only. Please write your social security number without hyphen ("-") on the identification number field of answer sheet.

1. At the beginning of the 1990s only about 30 countries were able to be reached through the Internet. Currently (1997) how many countries can be accessed into through the Internet?

A) about 40 countries  
B) about 70 countries  
C) about 100 countries  
D) about 130 countries  
E) about 160 countries

2. Driven by the popularity of services, the Internet’s growth rate has been astonishing. How many hosts in the world provide Internet services as of January 1997?

A) between 1.0 million and 4.9 million  
B) between 4.9 million and 6.9 million  
C) between 6.9 million and 8.9 million  
D) between 8.9 million and 10.9 million  
E) between 10.9 million and 20.0 million

3. The Internet provides many popular services. Which one of the following is NOT a service provided by the Internet?

A) Electronic Mail  
B) Spreadsheet  
C) Remote Access  
D) File Transfer  
E) World-Wide Web

4. The Internet is a “network of networks” that links computers around the world. These computers range from PCs and Macs to supercomputers, but they all use a set of rules called _________ to exchange information.

A) TCP/IP (Transmission Control Protocol/Internet Protocol)  
B) HTTP (Hypertext transfer Protocol)  
C) HTML (Hypertext Markup Language)  
D) WWW (World-Wide Web)  
E) JAVA
5. Before we can start using all of the resources on the Internet, we must become familiar with the Internet style addressing. Which one of the following is **NOT** a part of the Internet address?

A) User-Id  
B) Hostname  
C) @  
D) Domain  
E) To

6. Electronic mail (E-mail) allows us to communicate quickly and easily through the Internet. Which one of the following does **NOT** provide an E-mail function?

A) Pine  
B) Pegasus  
C) WordPerfect Office  
D) GroupWise  
E) Microsoft Office

7. **USENET** is a world-wide community of electronic Bulletin Board System (BBS) that is closely associated with the Internet. It is usually compared to the **LISTSERV**. Which one of the following is **NOT** a characteristic of the **USENET News** when compared to the **LISTSERV**?

A) It provides a computerized discussion forum.  
B) It requires to subscribe.  
C) It has a hierarchical name structure.  
D) It takes less disk space.  
E) It is better than LISTSERV.

8. **TELNET** allows you to access a remote computer system on the Internet as though your terminal was directly hooked up to it. To access a remote host using **TELNET** you need the following:

A) Internet name or address of a remote host  
B) A User account on the remote host  
C) A Local host on the Internet  
D) All of the above  
E) Only both A) and B)
9. FTP is used to accomplish high-speed file transfers between two computers on the Internet. Which one of the following is NOT a characterise of the FTP?

A) There is a special “anonymous” User-ID for FTP users available on some hosts.
B) If we wish to transfer files to or from a host computer on which we do not have a regular account, we enter our name as our User-ID.
C) If we wish to transfer files to or from a host computer on which we do not have a regular account, we enter our E-mail address as the password.
D) We can login in to a special account called “FTP” with a different home directory.
E) We can copy files from public access ftp sites using anonymous ftp.

10. Gopher was one of the more popular Internet applications. Gopher is a way of distributing information to a large and geographically diverse student body. Which one of the following is NOT a characteristic of the Gopher?

A) Gopher provides a very unique window in to the Internet.
B) Gopher offers browsing and an easy way to access information found on the Internet.
C) Gopher was originally designed to support more multi-media formats.
D) Gopher was originally written at the University of Minnesota.
E) To use Gopher, you either need to obtain a Gopher client program or you can use a public Gopher site via Telnet.

11. A major reason for the accelerated growth of the Internet in the last few years is the WorldWide Web (WWW, W3). Netscape can be a role model of all web browser. Which one of the following is NOT a reason for the popularity of the Netscape?

A) It can be gotten at a free charge.
B) It does not require a subscription.
C) It supports all other kinds of services on the Internet.
D) It supports to display graphic images.
E) It is supported by the federal government.

12. For the interaction of documents stored on computers across the Internet, we need a kind of web browser. In a graphical web browser program like Netscape Navigator or Microsoft Internet Explorer, which one of the following is NOT a component of a browser?

A) Menu Bar
B) Command Line
C) Inline Image
D) Scroll Bar
E) Hypertext and Hyperlink
13. With a World-Wide Web browser like Netscape we can use some other kind of services for the Internet. Which one of the following is NOT a service provided by Netscape?

A) SPSS  
B) Gopher  
C) FTP  
D) TELNET  
E) USENET News

14. The web is an example of ________ computing, in which networked computers share the work of a task.

A) PPP  
B) TCP/IP  
C) SAS  
D) Client/Serevr  
E) MIS

15. The operation of the Web relies mainly on **Hypertext** as its means of interacting with users. **Hypertext** is basically the same as regular text. The major difference between hypertext and regular text is that hypertext can be?

A) Stored  
B) Read  
C) Linked with other document  
D) Searched  
E) Deleted

16. **Hypermedia** is **hypertext** with a difference. Which one of the following does NOT describe **Hypermedia**?

A) Texts can contain links to other pieces of text.  
B) Texts can contain links to sounds, images, and movies.  
C) Hypermedia simply combines hypertext and multimedia.  
D) It supports statistical analysis tools.  
E) Images themselves can be selected to link to sounds or documents.
17. Web documents are ordinary text files that can be created with any word processing program. But they include tags that control their appearance. What is the standard language the Web uses for creating and recognizing Hypermedia documents?

A) C++  
B) HTML  
C) PASCAL  
D) COBOL  
E) FORTRAN

18. Users of the World-Wide Web retrieve documents from web sites or servers. Web clients and servers use a specific language to communicate with each other. What is this called?

A) HTML  
B) TCP/IP  
C) FTP  
D) HTTP  
E) URL

19. The World-Wide Web uses a special kind of address to represent Hypermedia links and links to network services. What is this called?

A) HTML  
B) TCP/IP  
C) FTP  
D) HTTP  
E) URL

20. Exploring the World-Wide Web requires some hardware and software resources. Which one of the following is NOT required for the exploring the Web?

A) Physical access to the Internet through Ethernet, LAN, or modem and telephone line  
B) A Web client program (Web browser)  
C) Database program  
D) Software for dial-up access to TCP/IP if you are using a modem  
E) Software for TCP/IP networking
APPENDIX G

STATISTICAL ANALYSIS PROGRAM
options ps=44 pageno=127 center nodate;
title1 'Statistical Analysis for Dissertation';
title2 'Youngtae Ryu';
data databook;
  infile 'a:\analysis.dat';
  input class $ 1 college $ 2 sex $ 3 age 4-5
    ce 10-11 ro 12-13 ac 14-15 ae 16-17
    style $ 18-21 score 22-23 logic $ 24 action $25;
label
class='Presentation Method'
ce='Feeling'
ro='Watching'
ac='Thinking'
ae='Doing'
style='Learning Style';
proc format;
  value $class T='Traditional' C='Computer-Based';
  value $style ACC='Accommodator' DIV='Diverger' ASS='Assimilator'
CON='Converger';
  value $college A='CAS' B='COBA' E='COE';
  value $sex F='Female' M='Male';
  value $logic F='Feeling' T='Thinking';
  value $action W='Watching' D='Doing';
run;
/*  Print raw data. */
proc print;
run;
/*  Print the summaries in table format such as frequency and mean. */
proc tabulate format=11.0;
  format class $class. style $style. college $college. sex $sex.
  format logic $logic. action $action.;
  class class style college sex logic action;
  var score;
  table class all, style*(score*mean*f=6.2 n*f=4.0)
all*(score*mean*f=6.2 n*f=4.0);
  table logic*(score*mean*f=6.2 n*f=4.0) all*(score*mean*f=6.2
n*f=4.0);
  table action*(score*mean*f=6.2 n*f=4.0) all*(score*mean*f=6.2
n*f=4.0);
  table class all, sex*(score*mean*f=6.2 n*f=4.0)
all*(score*mean*f=6.2 n*f=4.0);
table class all, college*(score*mean*f=6.2 n*f=4.0)
all*(score*mean*f=6.2 n*f=4.0);
  table style all, sex*(score*mean*f=6.2 n*f=4.0)
all*(score*mean*f=6.2 n*f=4.0);
  table style all, college*(score*mean*f=6.2 n*f=4.0)
all*(score*mean*f=6.2 n*f=4.0);
  table college all, sex*(score*mean*f=6.2 n*f=4.0)
all*(score*mean*f=6.2 n*f=4.0);
run;

/***************************************************************
Produce simple univariate descriptive statistics (n, mean, std),
plots to illustrate the distribution, and
a test to termine whether the data are normally distributed.
***************************************************************
proc univariate plot normal;
  var score;
run;

/* General Linear Model procedure */
proc glm;
  class style class;
  model score=class style class*style;
  means class style class*style/scheffe;
  format class $class. style $style.;

/* Simple main effects test of Class based on Learning Style */
contrast 'Class at Style_1' class 1 -1 class*style 1 -1;
contrast 'Class at Style_2' class 1 -1 class*style 0 0 1 -1;
contrast 'Class at Style_3' class 1 -1 class*style 0 0 0 1 -1;
contrast 'Class at Style_4' class 1 -1 class*style 0 0 0 0 1 -1;
run;

proc glm;
  class class style;
  model score=class style class*style;
  format class $class. style $style.;

/* Multiple Comparion tests of Learning Style */
contrast 'Ass. vs Con.' style 0 1 -1 0;
contrast 'Ass. vs Acc.' style -1 1 0 0;
contrast 'Ass. vs Div.' style 0 1 0 -1;
contrast 'Con. vs Acc.' style -1 0 1 0;
contrast 'Con. vs Div.' style 0 0 1 -1;
contrast 'Acc. vs Div.' style 1 0 0 -1;
/* Simple Main Effect tests of Learning Style based on Class */
contrast 'Style at Class_1'
  style 1 0 0 -1 class*style 1 0 0 -1,
  style 0 1 0 -1 class*style 0 1 0 -1,
  style 0 0 1 -1 class*style 0 0 1 -1;
0 0 -1,
1 0 -1,
0 1 -1;

contrast 'Style at Class_2'
  style 1 0 0 -1 class*style 0 0 0 1
0 0 -1,
1 0 -1,
0 1 -1;

/* Multiple Comparison tests of Learning Style within each Presentation Method */
/* Computer-Based Presentation Classroom */
contrast 'Com. Acc vs Com. Ass'
  class 0 0 style 1 -1 0 0
  class*style 1 -1 0 0 0 0 0 0;
contrast 'Com. Acc vs Com. Con'
  class 0 0 style 1 0 -1 0
  class*style 1 0 -1 0 0 0 0 0;
contrast 'Com. Acc vs Com. Div'
  class 0 0 style 1 0 0 -1
  class*style 1 0 0 -1 0 0 0 0;
contrast 'Com. Ass vs Com. Con'
  class 0 0 style 0 1 -1 0
  class*style 0 1 -1 0 0 0 0 0;
contrast 'Com. Ass vs Com. Div'
  class 0 0 style 0 1 0 -1
  class*style 0 1 0 -1 0 0 0 0;
contrast 'Com. Con vs Com. Div'
  class 0 0 style 0 0 1 -1
  class*style 0 0 1 -1 0 0 0 0;

/* Traditional Presentation Classroom */
contrast 'Tra. Acc vs Tra. Ass'
  class 0 0 style 1 -1 0 0
  class*style 0 0 0 0 1 -1 0 0;
contrast 'Tra. Acc vs Tra. Con'
  class 0 0 style 1 0 -1 0
  class*style 0 0 0 0 1 0 -1 0;
contrast 'Tra. Acc vs Tra. Div'
  class 0 0 style 1 0 0 -1
  class*style 0 0 0 0 1 0 0 -1;
contrast 'Tra. Ass vs Tra. Con'
  class 0 0 style 0 1 -1 0
  class*style 0 0 0 0 1 -1 0 0;
contrast 'Tra. Ass vs Tra. Div'
  class 0 0 style 0 1 0 -1
  class*style 0 0 0 0 1 0 -1;
contrast 'Tra. Con vs Tra. Div'
  class 0 0 style 0 0 1 -1
  class*style 0 0 0 0 0 0 1 -1;

run;

proc glm;
  class logic class;
  model score=logic class logic*class;
  format logic $logic. class $class.;
run;
proc glm;
   class action class;
   model score=action class action*class;
   contrast 'Class at Action_1' class 1 -1 class*action 1 -1;
   contrast 'Class at Action_2' class 1 -1 class*action 0 0 1 -1;
   format action $action. class $class.;
run;

proc glm;
   class class action;
   model score=action class action*class;
   contrast 'Action at Class_1' action 1 -1 class*action 1 -1;
   contrast 'Action at Class_2' action 1 -1 class*action 0 0 1 -1;
   format action $action. class $class.;
run;

/* Generate an output data set for Power Analysis */
proc glm outstat=glmdata noprint;
   class class style;
   model score=class style class*style;
run;

/* Power calculation with Macro: Power.sas should be run first */
%power (data=glmdata,
   out=powerout,
   effect=class
   calcs=power adjpow powci lsn,
   ss=ssl,
   alpha=.05);
run;

%power (data=glmdata,
   out=powerout,
   effect=style,
   calcs=power adjpow powci lsn,
   ss=ssl,
   alpha=.05);
run;

%power (data=glmdata,
   out=powerout,
   effect=class*style,
   calcs=power adjpow powci lsn,
   ss=ssl,
   alpha=.05);
run;

/* End of Main Program */
PURPOSE: Calculates the following power related measures:

- Power for an effect test
- Adjusted power and confidence limits
- Least significant number

The macro is invoked with the following statement:

```
%power(DATA=outstat_data_set, 
  OUT=output_data_set, 
  EFFECT=effect_name, 
  CALCS=calculations_to_report, 
  SS=type_sums_of_squares_to_use, 
  ALPHA=list_of_significance_levels, 
  N=list_of_sample_sizes, 
  SIGMA=list_of_standards_deviations, 
  DELTA=list_of_effect_sizes)
```

The OUTSTAT_DATA_SET is created by the OUTSTAT options in PROC GLM. All calculations are output to OUTPUT_DATA_SET. Calculations are done/reported for CALCULATIONS_TO_REPORT on EFFECT_NAME from OUTSTAT_DATA_SET with the corresponding TYPE_SUMS_OF_SQUARES_TO_USE.

The keyword parameters assigned in any order. These must be assign with the format:

```
keyword=values
```

Alpha is assigned a default value of 0.05 when no other value is specified. User defined value lists for n, sigma, and delta will have true values from the data prepended to them.

Outputted values of .N indicate statistics that were not calculated; values of .U indicate that the macro was unable to calculate the statistic.
%macro power(data=, out=, effect=, calcs=, ss=ss3, alpha=0.05, n=, sigma=, delta=);

%let calcs=%upcase(&calcs);
%let ss=%upcase(&ss);

* GET ERROR AND HYPOTHESIS DF AND SS FROM OUTSTAT DATA SET;
data _null_;  
set &data(where=(_type_ in ("&ss","ERROR")));
   end=lastobs;
   if _n_=1 then do;
      dfr=0;
      norig=0;
   end;
   norig+df;
   select(_source_);
   when ('ERROR') do;
      call symput('dfeorig',left(put(df,8.)));
      if ss gt 0 then
         call symput('sigorig',
                  left(put(sqrt(ss/df),14.2)));
         else call symput('sigorig','');
   end;
   when (upcase("&effect")) do;
      dfr+df;
      call symput('dfh',left(put(df,8.)));
      call symput('ssh',left(put(ss,14.2)));
      call symput('fsamp',left(put(f,14.2)));
   end;
   otherwise do;
      dfr+df;
   end;
   end;
   if lastobs then do;
      call symput('dfr',left(put(dfr,8.)));
      call symput('norig',left(put((norig+1),8.)));
   end;
run;
* PUT ORIGINAL DELTA INTO MACRO VARIABLE;
  data _null_
    delta=sqrt (&ssh/&norig);
    call symput('delorig',left(put(delta,16.4)));
    stop;
run;

* PREPEND VALUES FOR N SIGMA DELTA THAT
  OCCUR IN DATA TO USER-SPECIFIED VALUES;
  %let n=&norig &n;
  %let sigma=&sigorig &sigma;
  %let delta=&delorig &delta;

%put n=&n;
%put sigma=σ
%put delta=δ
%put alpha=α
%put dfeorig=&dfeorig;
%put sigorig=&sigorig;
%put dfr=&dfr;
%put dfh=&dfh;
%put ssh=&ssh;
%put fsamp=&fsamp;

* MACRO TO ADD COMMAS AFTER VALUES
  SPECIFIED FOR ALPHA, N, SIGMA, DELTA;
%macro comma(string,varname);
  %global &varname;
  %local count word;
  %let count=1;
  %let word=%qscan(&string,&count,%str( ));
  %let &varname=&word;
  %do %while (&word ne);
    %let count=%eval(&count+1);
    %let word=%qscan(&string,&count,%str( ));
    %if (&word ne) %then
      %let &varname=&&&varname, &word;
  %end;
  %put &varname = &&&varname;
%mend comma;

* CREATE COMMA DELIMITTED LIST FOR USER-SPECIFIED
  VALUES OF ALPHA, N, SIGMA, DELTA;
%let given=alpha n sigma delta;
%do i=1 %to 4;
  %let current=%scan(&given,ai,%str( ));
  *comma( &&current, &current);
%end;
* PERFORM CALCULATIONS:
  data &out;
  do alpha=&alpha;
    do number=&n;
      dfe=number-&df-1;
      do sigma=&sigma;
        do delta=&delta;
          * CALCULATE LAMBDA AND POWER;
            lambda=(number*delta**2)/(sigma**2);
            astar=1-alpha;
            fcrit=finv(astar,&dfh,dfe);
            if lambda>135 then power=1.0;
            else power=
              1-probf(fcrit,&dfh,dfe,lambda);
          * CALCULATE ADJUSTED LAMBDA AND
            CI FOR ORIGINAL DELTA;
            if delta=&delorig and
              index("&calcs","ADJPOW")>0 then do;
                lamadj=max(0,(lambda*(fcdfeorig-2)/&dfeorig)-&dfh);
                if lamadj>135 then adjpow=1.0;
                else adjpow=1-probf(fcrit,&dfh,dfe,lamadj);
            end;
            else if delta=&delorig then adjpow=.U;
            else do;
              adjpow=.N;
            end;
        end;
    end;
  end;
  end;
  * GET CI ON LAMBDA AND POWER;
    if index("&calcs","POWCI")>0 and
      adjpow not in (.N,.U) then do;
        lamlow=&dfh*(max(0,(sqrt(&fsamp)-sqrt(fcrit)))**2; 
        if lamlow>135 then powlow=1.0;
        else powlow=1-probf(fcrit,&dfh,dfe,lamlow);
        lamup=&dfh*(sqrt(&fsamp)+sqrt(fcrit))**2;
        if lamup>135 then powup=1.0;
        else powup=1-probf(fcrit,&dfh,dfe,lamup);
    end;
    else do;
      powlow=.N;
      powup=.N;
    end;
  * FIND LEAST SIGNIFICANT N;
    if number=&norig and
index("&calcs","LSN")>0 then do;
niter=&dfr+2;
lstar=(niter*delta**2)/(&dfh*sigma**2);

do until (diff<0.0000001);
niter=niter+1;
errn=niter-&dfr-1;
lstar=(niter*delta**2)/(&dfh*sigma**2);
diff=astar-probf(lstar,&dfh,errn);
end;

lsn=niter;
lsndfe=lsn-&dfr-1;
lamblsn=(lsn*delta**2)/(sigma**2);
astar=1-alpha;
fcrit=finv(astar,&dfh,lsndfe);
if lamblsn>135 then powlsn=1.0;
else powlsn=1-probf(fcrit,&dfh,lsndfe,lamblsn);
end;
else do;
lsn=.N;
powlsn=.N;
end;

output;

end; *delta;
end; *sigma;
end; *number;
end; *alpha;

label alpha='Type I Error Rate'
number='Sample Size'
sigma='Root Mean Square Error'
delta='Effect Size'
power='Power of Test'
adjpow='Adjusted Power'
powlow='Confidence Interval: Lower Limit'
powup='Confidence Interval: Upper Limit'
lsn='Least Significant Number'
powlsn='Power when N=LSN';

keep alpha number sigma delta
%if %index(&calcs,POWER)>0 %then %str(power);
%if %index(&calcs,ADJPOW)>0 %then %str(adjpow);
%if %index(&calcs,POWCI)>0 %then %str(powlow powup);
%if %index(&calcs,LSN)>0 %then %str(lsn powlsn);
run;

%let ssnum=%substr(&ss,3,1);
* PRINT RESULTS;
proc print data=&out noobs label;
  var alpha number sigma delta
    %if %index(&calcs,POWER)>0 %then %str(power);
    %if %index(&calcs,ADJPOW)>0 %then %str(adjpow);
    %if %index(&calcs,POWCI)>0 %then %str(powlow powup);
    %if %index(&calcs,LSN)>0 %then %str(lns powlan);
  title1 "Power Calculation for effect %upcase(&effect)";
  title2 "Type &ssnum Sums of Squares";
run;
title;
%mend power;
APPENDIX H

DATA and OUTPUT
### Raw Data for Statistical Analysis

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