RECOMMENDATIONS FOR A SOFTWARE APPLICATION BASED ON INDIVIDUAL DIFFERENCES

by

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BASED ON INDIVIDUAL DIFFERENCES

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has been approved

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ABSTRACT

The purpose of this research was to document individual differences while using a specific computer software application and to make recommendations for a new interface based on those differences. Differences between users account for a wide range of human factors considerations. The individual differences of concern in this research were level of computer anxiety, cognitive style, and method of problem-solving. The research hypotheses were:

1. There is no relationship between level of computer anxiety and cognitive style.
2. There is no relationship between level of computer anxiety and method of problem-solving for a computer-based task.
3. There is no relationship between cognitive style and method of problem-solving for a computer-based task.

Level of computer anxiety was documented using the Computer Anxiety Index (CAIN). The Myers-Briggs Type (MBTI) Indicator was used to determine cognitive style. Method of problem-solving was decided using concurrent verbal protocol analysis.

Although correlations were weak, trends were present. Participants with Introversion (I), Sensing (S), Thinking (T), and Judging (J) preferences demonstrated a higher average level of computer anxiety. They also averaged higher scores on task completion and higher percentages of problem-solving time using reading methods. Conversely, participants with Extraversion (E), iNtuition (N), Feeling (F), and Perceiving (P) preferences had a lower average level of computer anxiety, averaged lower scores on the tutorial, and averaged a higher percentage of time using non-reading problem-solving methods. The researcher made recommendations based on the finding that participants with certain preferences read the manual less, which resulted in poorer performance on the tutorial. The recommendations were aimed at bringing small amounts of text to the computer screen. This would provide hints needed by participants who tended not to read printed manuals.

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INTRODUCTION

Statement of Problem

The human factors issues related to computer interfaces have changed. Previously, one needed to know a special programming language to communicate with a computer. Current software applications use cascading menus and icons that, when selected, automatically enter procedures written in a computer language. New interfaces using icons have been termed Graphical User Interfaces. The math and language abilities required for using earlier interfaces are being replaced by the need for word and object recognition. The type of knowledge needed to interface with computers could dictate the type of person who excels at using the interface.

The problem with current research is that conflicting results have been reported for an individual's personality type and her interest in computers versus her ability to write applications for computers. In "Computer Use and Cognitive Style" by W. Paul Jones, it was reported that "Thinking" persons, as identified by a questionnaire, were more likely to experiment with a new software application. Also, "Intuitive" persons reported being more likely to purchase or borrow hardware or software and more likely to complete a major task with a computer (Jones 514-522). However, "The Myers-Briggs Personality Type and Its Relationship to Computer Programming" documented that "'Sensing' students performed better on programming assignments than 'Intuitive' students and that 'Judging' students achieved higher programming averages than 'Perceptive' students" (Bishop-Clark and Wheeler 358-370). The discrepancy between Intuitive persons being interested in trying new software and their programming performance could have resulted from the fact that using computer software required a different "type" of person than that required for writing applications.

Purpose of Research

The purpose of this research was to document individual differences while using a specific computer software application and to make recommendations for a new interface based on those differences. Individual differences between users can account for a wide range of human factors considerations. The recommendations have been derived from the relationship between individual differences in computer anxiety, cognitive style, and method of problem-solving.

The study named in the previous section addressed the issues of human-computer interface related to computer programming. However, the majority of computer users today do not have programming experience. A new type of computer user has emerged, and there was little literature available which supported or investigated cognitive patterns of these new users. Information about individual differences in computer anxiety, cognitive style, and method of problem-solving were used to make recommendations for a new computer software interface.

Overview

Level of Computer Anxiety

Level of computer anxiety was the first measure of individual differences in computer use applied in this research. A pre-test of computer anxiety level was administered to each participant. Maurer, co-developer of the Computer Anxiety Index, defined computer anxiety as, "The fear or apprehension felt by an individual when using computers, or when considering the possibility of computer utilization."

The basis of computer anxiety is continually changing. Initially, there were few software applications available and most interface with computers was through programming languages such as BASIC or PASCAL. Therefore, the level of computer anxiety was heavily dependent on programming ability. With the increase of available software, a person does not necessarily need to know a programming language to use a computer. However, anxiety still exists. Results from the study "Teacher Education Students and Computers: Prior Computer Experience, Occurrence, and Anxiety" showed that "Gender, year, major, and prior experience all had significant main effects on computer anxiety" (Liu, Reed and Phillips 457-467). In this thesis, level of computer anxiety was compared to cognitive style, then method of problem-solving, to determine if there was a relationship.

Cognitive Style

Cognitive style was the second measurement of individual differences that was used in this thesis. Participants were asked to complete a second pre-test of cognitive style. Cognitive style has been defined by Igbaria and Parasuraman as, "...the characteristic processes used by an individual in the acquisition, analysis, evaluation and interpretation of data used in decision making". Carl Jung developed a theory of cognitive styles that has come to be known as the theory of personality types. These "types" are based on cognitive styles. According to Myers & Myers, "Type theory is related to academic achievement, aptitude, application, and interest." Personality type is commonly used in schools in an attempt to assess individual cognitive styles and determine why all students do not learn the same amount in the same situation. The relationship between each participant's cognitive style and his level of computer anxiety and method of problem-solving has been investigated.

Method of Problem-solving

Concurrent verbal protocol analysis was used to document the method of problem-solving used by each participant. Each participant's reaction to mistakes while completing a section from a tutorial for an unfamiliar software application was video taped and analyzed. The tutorial was flawed. Therefore, it was impossible to complete the tutorial correctly without prior knowledge of the computer application. Ericsson and Simon maintained that, "One means frequently used to gain information about the course of the cognitive process is to probe the subjects' internal states by verbal methods." This was the final assessment of individual differences for this research.

Organization

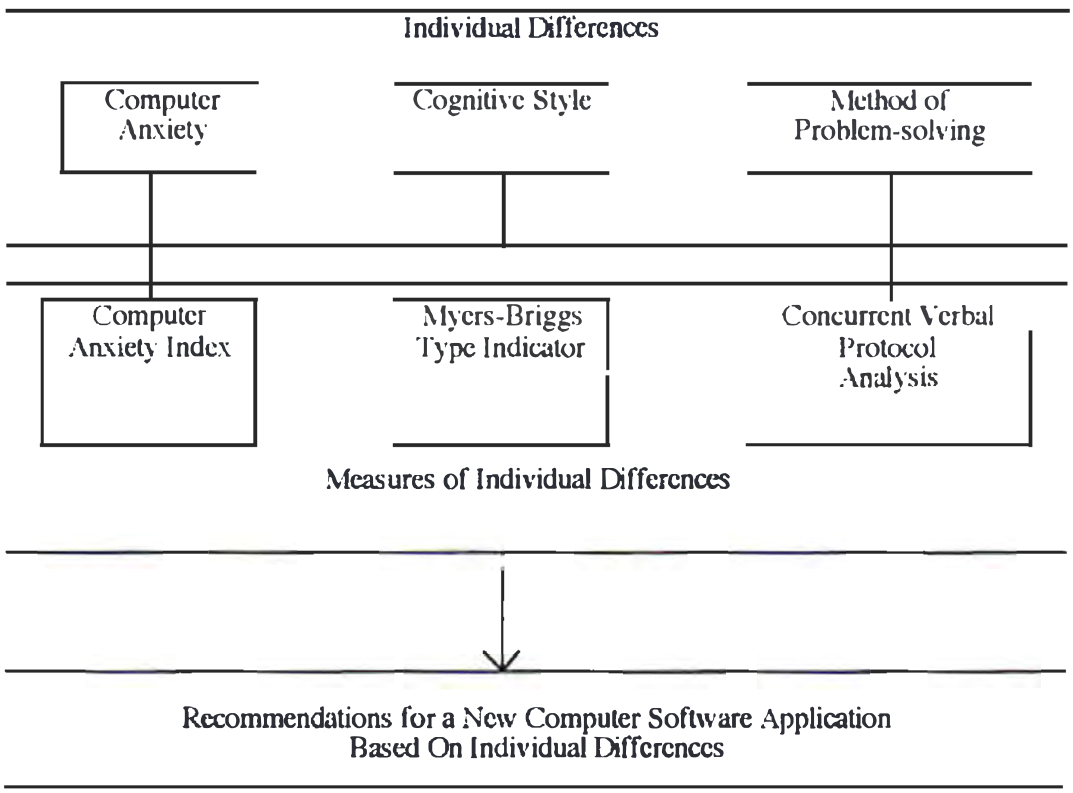


Fig. 1. Organization

Research Hypotheses

1. There is no relationship between level of computer anxiety and cognitive style.
2. There is no relationship between level of computer anxiety and method of problem-solving for a computer-based task.
3. There is no relationship between cognitive style and method of problem-solving for a computer-based task.

Definition of Terms and Abbreviations

1. CAIN (Computer Anxiety Index) - used to measure level of computer anxiety.
2. Cognitive style - "...the characteristic processes used by an individual in the acquisition, analysis, evaluation and interpretation of data used in decision making" (Igbaria and Parasuraman 373-388).
3. Computer anxiety - "...the fear or apprehension felt by an individual when using computers, or when considering the possibility of computer utilization" (Simonson, et al. 247).
4. Computer applications - a computer program designed for a specific task or use (673+713).
5. Icon - A picture on a screen representing a specific command (American Heritage College Dictionary)(673+713)
6. Introspection - Contemplation of one's own thoughts, feelings and sensations; self-examination (673+713).
7. MBTI (Myers-Briggs Type Indicator) - used to measure cognitive style according to the psychological types described by Carl Jung.
8. Problem-solving - To work out a correct solution to a problem (American Heritage College Dictionary)(673+713)
9. Protocol analysis - "A variant of introspection is protocol analysis in which the experimenter or the subject keeps a written or tape-recorded record of his or her

perceived thought process. This permanent record can be analyzed for frequency counts of certain words, first or last occurrence of a word or behavior, or clusters of behavioral patterns" (Schneiderman).

Assumptions

1. It was assumed that all participants reported their level of computer anxiety to the best of their ability for this research.
2. It was assumed that all participants answered all questions on the Myers-Briggs Type Indicator to the best of their ability for this research.
3. It was assumed that all participants used their natural problem-solving methods for this research.
4. It was assumed that all participants completed the tutorial to the best of their ability for this research.
5. It was assumed that all participants had the same amount of previous knowledge using Infini-D since it was a requirement that participants had never used the application.
6. It was assumed that prior experience with a Macintosh computer was not necessary since the application was already open and all interaction with the operating system was not documented.
7. It was assumed that the computer application was stable and responded consistently to all user input.

Limitations

1. Due to the scope of the research, certain variables were limited. Therefore, the age of participants was limited to eighteen and above to simplify the approval process for human testing.

2. Participants were recruited randomly in the Memorial Union at Arizona State University. Signs were posted around the sign-in table on the second floor of the Memorial Union. This was a limitation because everyone on campus did not have an equal opportunity to participate in this research.

3. The research groups were half female and half male. This limitation was based on the assumption that recent studies find differing computer anxiety levels between genders. Having groups that were half female and half male insured that each gender was equally represented.

4. Participants cannot have used Infini-D previous to this research. If any participants had used the software before, their ability to complete the tutorial would have been enhanced.

5. The revision of the manual (appendix A) must be used when repeating this research. Lesson 1: Building a Simple Model from the Infini-D Tutorial Manual was used to provide the tasks for the protocol analysis. The tutorial had been altered from its original printed form. Portions of the computer application had been updated but the tutorial had not. The researcher added the new icons to the tutorial. Additional icons were added if they were referred to but not pictured. This was necessary because the tutorial made reference to descriptions of icons in the User's Manual. The User's Manual was not provided because it would add too many variables to the processes of problem-solving. Any further references to the User's Manual or other sections of the tutorial were also deleted. The revised tutorial has been included (appendix A) to aid anyone who wishes to repeat this research.

6. If this research were replicated, it would be imperative to use version 2.6 of Infini-D since older or newer versions might differ.

REVIEW OF LITERATURE

Overview of References

To begin this research, literature in three general areas was reviewed: literature related to quantifying computer anxiety, literature related to quantifying cognitive style, and literature relating to quantifying method of problem-solving. As this research progressed, literature related to human factors issues of the computer interface was reviewed. The current literature review details the most pertinent information found.

Quantifying Computer Anxiety

Computer anxiety was used in this research as a measurement of individual differences in computer use. Many of the studies that were reviewed attempted to link computer anxiety to age, gender, and computer experience. These studies were used as a reference for the type of computer anxiety test uses, not as an attempt to determine the cause of computer anxiety among participants.

The Effect of Age, Gender, Race, and Prior Experience on Computer Anxiety

"Computer Anxiety: Sex, Race and Age", by Gilroy and Desai tested 270 undergraduate students using the Oetting Attitudes toward Computers Scale, Form A. According to the authors, this test has been extensively validated but the results have not been published. Participants were also asked for information regarding sex, age, race, and xperience with computers and formal courses in computers. The findings indicated, "...that sex, formal course, and experience were significantly predictive of computer anxiety $p<0.01$), with neither race nor age attributing for significant variance" (Gilroy 711-719). lales with formal course experience had significantly lower anxiety, while females with ormal course and computer experience had significantly lower anxiety (Gilroy 711-719).

The study "Teacher Education Students and Computers: Prior Computer Experience, Occurrence, and Anxiety" by Lui, Reed, and Phillips tested 914 teacher education students with a modified version of Spielberger's Self-Evaluation Questionnaire. The questionnaire was a 20-item, 4-point Likert scale. The reliability and validity of the test were not stated. The results showed that, "Gender, year, major, and prior experience all had significant main effects on computer anxiety" (Liu, Reed and Phillips 457-467). Generally, males without prior experience had lower anxiety than females without prior experience.

The study "Age Differences in Computer Anxiety: The Role of Computer Experience, Gender and Education" by Dyck and Smither compared 219 subjects 30 years and younger from universities and community colleges in central Florida to 203 students 55 years or older from the same area who were enrolled in continuing education courses. The tests used were a Computer Attitude Scale, Computer Anxiety Scale, a Demographic Questionnaire, and a Computer Experience Questionnaire. The Computer Attitude Scale was a 30 item 4-point Likert scale with three subscales each consisting of ten questions. The different sections were: Computer Anxiety, Computer Confidence, and Computer Liking with alpha coefficients of .87, .91, and .91, respectively. The Computer Anxiety Scale was a 20 item 5-point Likert scale. The scale had a test-retest reliability coefficient of .77 and an internal consistency alpha coefficient of .97. This test was developed to measure computer anxiety in specific situations. The Demographics Questionnaire consisted of three questions: year of birth, number of years of formal education, and gender. The Computer Experience Questionnaire was a modified version of a questionnaire developed by Heinssen, Glass and Knight. It consisted of 14

questions t

listed. The results showed that the older adults had less anxiety and more positive attitudes towards computers than the younger adults tested. In both groups, those with more computer experience had less computer anxiety. Finally, results proved that, "No gender differences were found for computer anxiety or computer attitude when computer experience was controlled" (Dyck and Smither 239-248).

The Effect of Formal Computer Instruction on Computer Anxiety

In the study "Changes in Computer Anxiety in a Required Computer Course" by Paivi Hakkinen, 29 first-year students of education were tested at the beginning and end of a basic computer science course. The test consisted of a three-part attitude measurement questionnaire originally designed by Rosen, Sears, and Weil (1987). The first part dealt with anxiety related to computers, the second part dealt with attitudes towards computers, and the third part focused on thoughts and feelings related to computers. Each part of the questionnaire consisted of 20 questions. The reliability and validity were not reported. After the computer science course, students had a reduced level of anxiety and more positive attitudes towards new technologies and computers.

The study "Effects of an Introductory Versus a Content-Specific Computer Course on Computer Anxiety and Stages of Concern" by Overbaugh and Reed consisted of 20 graduate students enrolled in a 16-week introductory computer course and 15 graduate students enrolled in a 16-week content specific computer course, 10 of whom had prior computer courses. The population consisted of preservice and inservice teachers who were interested in introducing a new technology (computers) into the area they were teaching, either for management or instruction of their courses. The subjects were asked to complete a self-evaluation questionnaire about computer anxiety before the treatment. The questionnaire about computer anxiety was a modified version of Spielberger, O'Neill, and Duncan's Self-Evaluation Questionnaire. The original anxiety assessment instrument, a 20-question, 4-point Likert-scale instrument designed to reflect how respondents feel, was reworded to evaluate computer anxiety. For example, the item "I feel tense" was changed to "I feel tense when I work with the computer." The validity of the modified test was established initially by a board of experts. The reliability was shown to be very high with coefficient alpha = .91 and .93, respectively, by two tests performed by Reed and Palumbo. In both groups, computer anxiety decreased significantly after participating in the computer course.

Quantifying Cognitive Style

A review of current literature relating cognitive style to computer use showed that the Myers-Briggs Type Indicator (MBTI) was the most frequently used. The MBTI measured a person's personality based on four scales: Extraversion-Introversion (E-I), Sensation-iNtuition (S-N), Thinking-Feeling (T-F), and Judgment-Perception (J-P) (Carlyn 461-473).

Assessment of Cognitive Style

In the Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator by Myers and McCaulley, the four scales of the MBTI were defined.

> Extraversion-Introversion (EI): "Extraverts are oriented primarily toward the outer world; thus they tend to focus their perception and judgment on people and objects. Introverts are oriented primarily toward the inner world; thus they tend to focus their perception and judgment on concepts and ideas."
>
> Sensing-iNtuition (the "intuition" preference is denoted by "iNtuition" in all Myers-Briggs documentation because it is represented by a "N" when referred to in the abbreviation) (SN): "The SN index is designed to reflect a person's preference between two opposite ways of sensing (S), which reports observable facts or happenings through one or more of the five senses; or one may rely more upon the less obvious process of iNtuition (N), which reports meanings, relationships and/or possibilities that have been worked out beyond the reach of the conscious mind.
>
> Thinking-Feeling (TF). "The TF index is designed to reflect a person's preference between two contrasting ways of judgment. A person may rely primarily on thinking (T) to decide impersonally on the basis of logical consequences, or a person may rely on feeling (F) to decide primarily on the basis of personal or social values."
>
> Judgment-Perception (JP). "The JP index is designed to describe the process a person uses primarily in dealing with the outer world, that is, with the extraverted part of life. A person who prefers judgment (J) has reported a preference for using a judgment process (either thinking or feeling) for dealing with the outer world. A person who prefers perception (P) has reported a preference for using a perceptive process (either S or N) for dealing with the outer world" (Myers and McCaulley).

Myers and McCaully also included information about administering, scoring, and interpreting the MBTI. Correlations between the MBTI and many other tests were reported in the chapter on validity.

Gordon Lawrence's "A Synthesis of Learning Style Research Involving the MBTI" provided an overview of the MBTI's use in quantifying teaching methods, learning methods, and academic aptitude. Many of the mentioned studies presented results that could have been of interest, but did not directly relate to the issues addressed by this thesis. Two studies involving Sensing-iNtuition preferences were discussed in the overview. In a 1971 study by Smith and a 1981 study by Hoffman, Waters and Berry, it was shown that:

> "...sensing types showed a significant preference for learning by computer-assisted instruction, with Introversion Sensing types preferring it most. Hoffman, Waters and Berry found that sensing types completed the CAI portion of the course significantly sooner. Intuitive types in their study not only rated the instruction lower, and were slower at completing it, but they were also dropping out at a disproportionately high rate until the course was changed -- mainly by including more discussion and dialogue."

Lawrence claimed to have been able to locate only one study relating Thinking/Feeling preferences to cognitive style. A 1973 study by Carlson and Levy was cited in the overview. In that study:

> "Carlson and Levy predicted that Howard University students would differ by type on short-term memory tasks. The predictions were supported. Introverts with thinking (IT's) were better at remembering digits than Extraverts with Feeling (EF's). On memory for faces EF's were better than IT's. Geometric shapes bearing numbers were remembered better by IT's, while shapes bearing names were remembered better by EF's."

These studies did not relate directly to computer use, but they highlighted some individual differences that could have been associated to various types defined by the Myers-Briggs Type Indicator.

In Carland & Carland's study, "Cognitive Styles and the Education of Computer Information Systems Students," the MBTI was administered to 92 university level computer information system students. The classification of students according to personality type was used to determine its impact on the university and the educational process. The dimensions of the MBTI were grouped into "cognitive combinations" defined by Keirsey and Bates. The groups were Sensing-Perceiving, an individual who negotiated well and was good in a crisis; Sensing-Judging, an individual who was a traditionalist or a stabilizer; Intuitive-Feeling, an individual who was personal and personable; and Intuitive-Thinking, an individual who was a visionist. Carland & Carland maintained that the study could not have been generalized outside Western Carolina University, where the study took place. However, the authors noted that the Sensing-Perceiving students in higher education tended to have the lowest correlation between academic ability and grade point average. "They are underachievers. Sensing-Perceiving students need physical involvement in learning, hands-on experience, activity and competition, and to entertain and be entertained" (Carland and Carland 114-126).

Cognitive Style and Programming Ability

In "The Myers-Briggs Personality Type and Its Relationship to Computer Programming", it was suggested that "of the many cognitive style and personality instruments that exist, the MBTI should be the basis for cognitive style research in the area of information systems" (Bishop-Clark and Wheeler 358-370). In this research, a pilot study of 24 students and a follow-up study of 114 students taking an introductory computer programming course were given the MBTI on the first day of class. The results showed that "'Sensing' students performed better on programming assignments than 'iNtuitive' students and that 'Judging' students achieved higher programming averages than 'Perceptive' students (Bishop-Clark and Wheeler 358-370).

Cognitive Style and Software Use

In "Computer Use and Cognitive Style," it was shown that " Using the Myers-Briggs Type Indicator to assess cognitive style, this study found a relationship between style preferences and selected computer use and attitude variables in a population of university students" (Jones 514-522). In this study, 140 students enrolled in upper-division undergraduate and graduate courses were administered the MBTI along with a questionnaire about computers and the probability of their use. The results showed that two of the four cognitive styles associated with the MBTI were related to the level of computer use. Persons who had a strong preference for logical and analytical problem-solving, which exemplified a "Thinking" person, indicated on the computer use questionnaire as being more likely to experiment with a new software application. Persons who had a strong focus on more iNtuitive perception reported being more likely to purchase or borrow hardware or software and more likely to complete a major task with a computer (Jones 514-522).

Quantifying Method of Problem-solving

Reliability and Validity of Protocol Analysis

The study, "Understanding and Evaluating Measures of Computer Ability: Making a Case for an Alternative Metric" by Robin H. Kay, used verbal protocol analysis as a way to evaluate computer ability as a process. Computer ability was dynamic and changed while the subjects learned a new software application. Kay maintained that, "Previous researchers have developed computer ability measures intended to reflect a student's skill level". Verbal protocol analysis provided insight as to the methods of learning or task completion.

A well-cited book in the area of protocol analysis was, Protocol Analysis by Ericsson and Simon. The authors maintained that, "...concern for the course of the cognitive processes has revived interest in finding ways to increase the temporal density of observations so as to reveal intermediate stages of the process. One means frequently used to gain information about the course of the cognitive process is to probe the subjects' internal states by verbal methods." They offered support for the reliability and validity of this type of research. In a discussion about "hard" versus "soft" data the authors argued that new technological advances such as video and tape recorders allowed the raw data to be preserved in "hard" form.

Forms of Protocol Analysis

Software Psychology by Ben Schneiderman stated that "The simplest form of research in software psychology is introspection, in which the experimenters or subjects simply reflect on how they write, study and debug applications or how they use terminals. This form of organized thinking often produces insights into the programming process or new ideas for improved syntax. A variant of introspection is protocol analysis in which the experimenter or the subject keeps a written or tape-recorded record of his or her perceived thought process. This permanent record can be analyzed for frequency counts of certain words, first or last occurrence of a word or behavior, or clusters of behavioral patterns."

The study by Page and Rahimi "Concurrent and Retrospective Verbal Protocols in Usability Testing: Is there a value in collecting both?" addressed two forms of verbal protocol analysis. Concurrent verbal protocol required the subject to verbalize all thoughts while completing the specific task. Ericsson and Simon claimed that, "...cognitive processes are not modified by these verbal reports, and that task-directed cognitive processes determine what information is heeded and verbalized." Retrospective verbal protocol required the subject to reflect orally on the task after completing it. Ericsson and Simon maintained that, "A durable memory trace is laid down of information heeded successfully while completing the task. Just after the task is finished, this trace can be accessed from Short Term Memory (STM), at least in part, or retrieved from Long Term Memory (LTM) and verbalized. Retrospective reports based on information in LTM required an additional process of retrieval that displayed some of the same kinds of error and incompleteness that are familiar from experimental research on memory."

Human Factors Issues of the Computer Interface

In Cognitive Aspects of Computer Supported Tasks by Yvonne Waern, individual differences and their effect on the design of Human-Computer interfaces were discussed. Waern stated that:

> "Another aspect which may not seem to have as much direct bearing on the actual use of a computer system, concerns cognitive and learning styles. But since all users have to start by learning the computer system, individual differences on these counts may have some bearing on designing systems which are "easy to learn" by different types of people".

Three suggestions are made for designing for individual differences:

> "One way is to let the user define his interface himself, so that he could use the kinds of commands, symbols or interactions he is used to. This approach calls for a user who understands what he wants to do, and only needs to change the names of the known functions. However, this would be impractical when several users collaborate in learning a particular system. An apparently attractive research idea, just now involves adapting the system according to the user more or less automatically. This approach is more difficult than the one just described. It not only requires some parapsychological powers on the part of the system designer, who has to predict what the user might need, but also requires the system to detect the important attributes of the user to which the system is supposed to adapt. A better idea might therefore be to adapt not the system itself but its metacommunication according to the level of knowledge of the user. It might be easier to build an 'explanatory shell' to take care of differences, than to build a totally new system. Many systems incorporate a facility by which the user can decide how much help information he wants about system use" (Waern 307-320).

Norman, in his book The Psychology of Menu Selection, described the cognitive flow necessary for the human-computer interface. He stated that:

> "Models of the human-computer interface depend heavily on cognitive psychology. The psychological processes of attention, memory, information processing, decision making, and problem-solving must be taken into account. One of the most important features in such models is the flow and feedback of information through the interface. The user needs information from the computer, and the computer cannot function without information from the user. A major component of this interaction is the flow and control of information. The computer gives information to prompt the user for input, and the user supplies input that directs the subsequent operations. Smooth

operation requires a timely flow of information that is relatively free of error states in the machine and in the user."

Norman includes diagrams of interaction and methods for developing hierarchical menu structures. He also provides guidelines for prototyping and testing menu systems. This book will be used as a reference for understanding the requirements for cognitive flow in a human-computer interface.

In A Guide to Usability: Human Factors in Computing, recommendations for screen design were discussed (Preece 144). The following recommendations were made in various topic areas:

"Amount of information presented - minimize the total amount of information by presenting only what is necessary to the user.

Grouping of information - techniques for grouping are color coding, graphic borders around different groups of information, and highlighting using reverse video or brightness.

Highlighting of information - can be achieved by flashing, reverse video, underlining, making the information bolder and brighter, using a color that stands out from the rest of the screen.

Standardization of screen displays - it is important to lay out screens in a way that will enable users to know where to find a given piece of information.

Presentation of text - conventional upper and lower case text can be read about 13 per cent more quickly than all upper case, uppercase characters are most effective for items that need to attract attention.

Icons - when designing icons it is important to take into account: the context in which they are used, the task domain for which they are used, the nature of the underlying object that is represented and the extent to which one icon can be discriminated from other icons displayed.

Color - color can be effective for: segmenting a display into separate regions, search and detection tasks particularly for inexperienced users, and enhancing the legibility of a color symbol against its background. However, color should be used conservatively: too many colors clutter up the screen, increasing search times" (Preece 144).

Other recommendations for the development and testing of computer interfaces were iscussed. This book covered all aspects of human-computer interaction from the keyboard to the types of technical support needed for various systems.

Summary of Reviewed Literature

The reviewed literature was primarily in the form of journal articles. Many of the books relating to these subjects provided information that was not consistent with the facets of current software applications. The introduction of graphical user interfaces and icons has changed the type of computer interfaces currently used. Therefore, articles from recently released journals were cited because of their coinciding research. However, books were cited because the recommendations and guidelines for some of the topic areas have remained unchanged.

METHODOLOGY

Theoretical Framework

The theoretical framework for this research was derived from the theories set forth by Robin H. Kay in his study "Understanding and Evaluating Measures of Computer Ability: Making a Case for an Alternative Metric". He maintained that previously documented measures of computer skill were invalid. His theory was that, "A process-centered metric based on actual behaviors and responses is needed if researchers are to accurately examine the mechanisms of human-computer interaction in the context of recent developments in cognitive science research."

Introduction

Kay's research divided procedure into two parts. In the first part, the participants were required to complete a short questionnaire on, "...their intentions to use computers, affective and cognitive attitudes, sense of control over the computer, and learning style" (Kay 270-281). This was followed by a detailed interview about the subjects' understanding and use of computer software and an open ended interview about, "...perceptions of how they approached different learning tasks" (Kay 270-281). The second part of the study was, "...to observe the subjects' developmental process of learning a new software application" (Kay 270-281). The author accomplished this by a process similar to protocol analysis where the subjects were asked to think aloud for 60 minutes while "learning" the Lotus 1-2-3 software application (Kay 270-281). Unlike protocol analysis, the subjects were given hints when they were unable to proceed. Kay states that the methodology for the study, although open to possible biases, "...is designed to reveal individual differences, if any exist." Reliability and validity of the measures used were not included in the description of the study. In the interest of repeatability, the researcher investigated different methods for documenting individual differences in computer anxiety, cognitive style, and method of problem-solving. The search for appropriate measures of individual differences for this research was detailed in review of literature. The theoretical framework for the development of each testing method chosen varied and is outlined separately in the following sections.

Theoretical Framework for Development of the Computer Anxiety Index (CAIN)

The CAIN was included as part of the Standardized Test of Computer Literacy because it had been demonstrated that cognitive computer competencies were difficult for extremely computer anxious students to acquire" (Simonson, et al. 247). The authors developed a large number of statements that they believed to represent a person's feelings about computers. In a pilot study, they administered the items to two groups. One group was computer literate; the other group was not. The authors chose the statements that were the best discriminators between the computer literate and non-computer literate subjects. They then produced a revised version of the Index and tested it to produce the current version of the Index (Simonson, et al. 247). The CAIN was used in conjunction with the Myers-Briggs Type Indicator to determine if there was a correlation between level of computer anxiety and cognitive style.

Theoretical Framework for Development of the Myers-Briggs Type Indicator (MBTI)

The theoretical framework for the MBTI was based on Carl Jung's theory of personality types. The MBTI was developed to measure the variables of Jung's personality types. According to Marcia Carlyn in "An Assessment of the Myers-Briggs Type Indicator", the underlying assumption was that everyone had a natural preference for one or the other pole of each of the four indices. The indices were defined as the following. The Extravert-Introvert was designed to measure the person's preferred orientation to life. Extraverts oriented themselves to the outer world of objects, people, and action. Introverts tended to concentrate on the world within and often detached themselves from the outer world. The Sensing-INtuition index was designed to measure the person's preferred way of perceiving things. Sensing persons acquired information concretely through their five senses. iNtuitive persons liked to deal with abstractions. The Thinking-Feeling index was designed to measure a person's preferred way of making decisions. Thinking persons relied on logic, order, and analysis. Conversely, feeling persons analyzed subjective impressions and based their judgments on personal values. The Judging-Perceptive index was designed to measure the person's preferred way of dealing with the outside world. Judging types were organized and lived systematically in a planned, orderly way. They aimed to regulate life and control it. Perceptive persons were flexible and open-minded and went through life in a spontaneous manner. They aimed to understand life and adapt to it (Carlyn 461-473).

Theoretical Framework for Use of Concurrent Verbal Protocol Analysis

Encoding of concurrent verbal reports was based on the theory that the human brain encoded and stored information in two ways; short term and long term memory (Ericsson and Simon Hayden 1993). Short Term Memory (STM), also referred to as working memory, stored a small amount of data for a short period of time, but was immediately accessible. Little encoding was used since the information was constantly being overwritten. Long Term Memory (LTM) stored a large amount of data for a long time, but had a long retrieval time. This was due to the encoding processes used to select important information to store in LTM. Concurrent verbal reports made use of STM by documenting the information before it was lost or replaced by new information. This provided evidence of cognitive processes which were often forgotten or overlooked when the activity was completed and reflected upon (Ericsson and Simon 1993).

Selection of Tests

The following tests or forms of testing were chosen after reviewing related literature and the theoretical background for their development. These tests were chosen in an attempt to model Kay's research. Kay used non-published measures of computer anxiety and learning style. Therefore, published measurements of computer anxiety and cognitive style were located. Also, Kay reported using a process similar to protocol analysis. A specific type of protocol analysis was chosen to document the method of problem-solving for this research.

Selection of Appropriate Computer Anxiety Test

The tests listed in the literature review were each researched in the Mental Measurement Yearbooks. Only one computer anxiety test was still in print and available. It was the Computer Anxiety Index (Version AZ) Revised (Simonson, et al. 247). This test was a 26-item 6-point Likert scale test designed to measure computer-related anxieties by recording the respondent's feelings towards computers and their use. Respondents answered the questions by selecting an answer ranging from "strongly agree" to "strongly disagree". The intended population was high school and college students taking a first course in computer literacy. The Computer Anxiety Index (CAIN) could have been administered alone, but was part of the Standardized Test of Computer Literacy (STCL). The CAIN part of the STCL had high internal consistency (coefficient alpha = .94) and the test-retest reliability was .90 over a three-week interval (Kramer and Conoley 765).

Selection of Appropriate Cognitive Style Test

The intended sample population for this research was undergraduate university students. It was suggested in the reviewed literature (see page 12) that the Myers Briggs Type Indicator be used to document cognitive style when involving computers. On the basis of the populations used and recommendations by the previous studies, the Myers-Briggs Type Indicator was chosen as the quantifier of cognitive style. Form G self-scorable of the MBTI was a 94-item, multiple choice, self-report test. The intended population for the indicator was students in grades 9-16 and adults.

Selection of Appropriate Form of Protocol Analysis

Concurrent verbal report was chosen as the measure for determining the method of problem solving because of the type of data the reports provide. Concurrent verbal reports can document data which are often forgotten or overlooked when using retrospective verbal reports. The sources in the literature review suggested that concurrent verbal reports were the best method for documenting cognitive processes.

Design of Research

The design of this research was based on the work of Robin Kay. In his research, participants were administered pre-tests to document attitudes towards computer use and learning style. The participants then executed a type of verbal reports while completing computerized tasks. The same design was used in this thesis with the addition of a post-test questionnaire.

Pilot Group

Five students at Arizona State University were recruited through signs posted at various locations on campus. The signs read:

> Participants needed for a study. If you are an undergraduate or graduate student at Arizona State University, between the ages of 18 and 30, and have never used the computer application Infini-D -- your participation may be needed for a pilot study on December 7th, 8th, or 9th. The study will take two hours of your time -- for which you will receive $20.00. If you are interested in the possibility of participating, please call 804-0883.

There were two male participants and three female participants. Each participant was met individually in the lobby of the south Architecture building and escorted to the first testing room. The research assistant handed the participant a copy of the information letter (see appendix B) detailing the research. The research assistant then proceeded to read the information aloud and ask for questions about the study. Next, the participant was handed the Computer Anxiety Index, an answer sheet, and a sharpened pencil. The research assistant then read specific instructions (see appendix B) about completing the survey. The participant was asked if there were any questions about the task, then told to begin.

After collecting the survey, the research assistant handed the participant Form G self-scorable of the Myers-Briggs Type Indicator (MBTI) and a sharpened pencil. The instructions for completing the test appeared on the front page. However, the research assistant read the directions aloud from a separate sheet (see appendix B) to insure that all of the instructions were reviewed. The participant was asked for questions concerning the MBTI and told to begin. When the participant finished, the research assistant collected the MBTI and escorted the participant to the second testing room.

The researcher seated the participant in front of the notebook computer that was to be used to complete the protocol analysis. The researcher then adjusted the video camera so that the participant was not visible, but the computer screen was. The researcher read instructions (see appendix B) for completing the concurrent verbal protocol, then asked for questions concerning that portion of the test. The participant was asked to complete lesson 1 of the Infini-D Tutorial Manual while thinking aloud. It was suggested by Page & Rahimi (1995) that participants be given a warm-up verbal protocol analysis situation before the intended verbal protocol analysis begins. Section I was the warm-up. The verbal protocol for Section II was analyzed and used as data for method of problem-solving. When the participant finished the protocol, the researcher administered a self-report questionnaire (see appendix B). The self-report questionnaire was used to assess the participant's perceptions of the difficulty level and performance on the task, and document previous computer software use. The participant was thanked and paid $20.

Discussion of Results from the Pilot Group

All of the participants were documented as Extraverts and had relatively low levels of computer anxiety. Two of the participants had recruited their roommates for the pilot group. To reach a broader cross-section of Arizona State University students, participants for the follow-up group were recruited from the Memorial Union. Signs were posted around a sign-in table on the second floor of the Memorial Union and participants were recruited randomly. The students had to be over eighteen years old. Also, they could not have previously used Infini-D. Students were paid $10 for approximately two hours of their time. The researcher distributed a recruitment letter to anyone who inquired about the research (see appendix C).

The Computer Anxiety Index seemed to be appropriate and caused no problems in testing. The Myers-Briggs Type Indicator also seemed to be appropriate and caused no problems in testing. For the Protocol analysis, recording only task completion time and number of errors was not thorough enough to provide the type of information needed to make recommendations based on cognitive style. The tutorial had flaws. Every subject who completed the tasks made errors. However, the number of errors made while performing the tasks was misleading. The subject who made the most errors was the only one to obtain a result that resembled the target. Other participants encountered problems and either skipped that section or employed a number of strategies to solve the problem. These problem-solving strategies provided the most information about each participant's method of task completion. The problem-solving methods are listed in the Concurrent Verbal Protocol section of Scoring.

Follow-up Group

The follow-up group included 26 persons (13 female, 13 male). Two participants (P6 male, P8 female) did not complete both pages of the MBTI, therefore, their type could not be determined. Their data were dropped from the study. A third participant (P16 male had Extraversion, iNtuition, Feeling, Perceiving preferences) answered all of the written evaluations but could not perform any of the tasks using the computer. His data were dropped from the test because his method of problem-solving could not be determined for the tasks. Finally, data from 23 participants (11 male and 12 female) were evaluated for this research.

Once recruited, each participant was tested separately. The research assistant directed the reading of the information letter and the completion of the Computer Anxiety Index and the Myers-Briggs Type Indicator as explained in the pilot study. When the participant completed the written tests, the researcher read the instructions for completing concurrent verbal protocol and adjusted the video camera as mentioned in the pilot study. Once it was determined by the researcher that the participant understood the details of the protocol analysis, the participant was instructed to begin. When the participant was finished with the tutorial, the researcher distributed the self-evaluation questionnaire (see appendix C). The participant was thanked and paid $10. Two separate rooms were used so that two participants could be tested at the same time.

Scoring

The scoring of each measure of individual differences varied widely. The published tests were scored as suggested in the accompanying manual. The non-published measures were scored as suggested in the sources in the literature review.

Computer Anxiety Index

The tests were scored using the answer key provided by the developer of the test. Initial scoring was done by the primary researcher and checked by the research assistant.

Myers-Briggs Type Indicator

Results of the MBTI could have been evaluated to determine type-category scores or continuous scores. Type-category scores result in categorizing a person into one of 16 personality types. The purpose of this research was not to determine the personality type of participants. Therefore, the continuous scoring was more appropriate for this research since the person's cognitive style could be classified along the appropriate index. According to the literature review, continuous scores were used most often for assessing cognitive style associated to computer use. According to the Test Critiques Compendium (Keyser and Sweetland 327-336):

> "Conversion of data to continuous scores yields more consistent timates. Data obtained via two different procedures produced estimates of .76 to .82 (E-I), .75 to .87 (S-N), .69 to .86 (T-F), and .80 to .84 (J-P). The estimates of continuous scores retain data precision lost in the use of type-category scores, which accounts for the difference in reliability obtained from the two data types" (Carlyn 461-473).
>
> "Several trends in these correlations are noteworthy. The T-F scale exhibits the least reliability and the S-N, generally, the most. Recent findings also show increasing reliability with populations of increased age and intelligence" (McCaulley).

The continuous score for each individual was calculated by first determining the preference score described by the self-scorable test. These scores were then transformed into continuous scores. It was suggested by Myers and McCaulley that, "For E, S, T or J preference scores, the continuous score is 100 minus the numerical portion of the preference score. For I, N, F, or P preference scores, the continuous score is 100 plus the numerical portion of the preference score." The continuous scores were derived according to the previous suggestions.

Concurrent Verbal Protocol

The concurrent verbal protocol was timed and analyzed for evidence of problem-solving methods. Problem-solving methods were analyzed for four specific tasks in the tutorial.

The tasks were:

1. Sizing the table top.
2. Creating the table legs.
3. Locking the model.
4. Testing whether the model was actually locked.

The first two tasks resulted in errors because instructions of the tutorial were vague and incomplete. The third and fourth tasks resulted in errors because of a problem that was inherent in the application. For each problem area, the numbers 1-10 were recorded to document the type of problem-solving methods used by the participant.

The methods of problem-solving were:

1. Reread the current instructions only.
2. Reread the previous instructions.
3. Reread the entire section.
4. Look through the tutorial from the beginning.
5. Ignore the written material and click on different menus and parts of the screen.
6. Ignore the problem and skip to the next section.
7. Repeat the task without reading the instructions.
8. Repeat the task while reading the instructions.
9. Read ahead.
10. Close the window, open a new file to start over.

Use of each problem-solving method was documented. The duration of the practice of each method was timed. The percent of problem-solving time spent using each method was calculated by dividing each occurrence by the amount of time for the entire session. Occurrences of types of problem-solving were added together to represent the amount of time spent using each problem-solving method during completion of the tutorial.

The problem-solving methods were divided into two categories; reading and non-reading methods. The reading methods were 1, 2, 3, 4, 8, and 9. The non-reading methods were 5, 6, 7, and 10. The time spent using reading methods was added together. Similarly, the time spent using non-reading methods was added together. The concurrent verbal protocol results were consolidated into two scores; percent of problem-solving time spent using reading methods, and percent of problem-solving time spent using non-reading methods.

Task Performance

Task performance was rated on a scale of 0% to 100%. As previously stated, the participant who scored 0% was eliminated from the research because his problem-solving method could not be determined for any of the tasks. The tasks were scored as follows (refer to the tutorial in appendix B):

0% None of the tasks were completed correctly.

10% The table shapes were incorrectly constructed and none of the table legs were locked.

20% The table shapes were incorrectly constructed and one of the table legs was locked.

30% The table shapes were incorrectly constructed and two of the table legs were locked.

40% The table shapes were incorrectly constructed and three of the table legs were locked.

50% The table shapes were incorrectly constructed and all of the table legs were locked.

60% The table shapes were correctly constructed and none of the table legs were locked.

70% The table shapes were correctly constructed and one of the table legs was locked.

80% The table shapes were correctly constructed and two of the table legs were locked.

90% The table shapes were correctly constructed and three of the table legs were locked.

100% The table shapes were correctly constructed and all of the table legs were locked.

Documentation

Final data from all of the participants were recorded and are presented. Each participant's results from the Myers-Briggs Type Indicator were recorded in the test booklet. All participants' preference scores for the four dimensions of the Myers-Briggs Type Indicator were then organized in a single table. Also, each participant's computer anxiety score was recorded in a table sorted by participant number. The protocol analysis was recorded on video tape. The protocol analysis was evaluated according to Protocol Analysis: Verbal Reports as Data (Ericsson and Simon Hayden 1993). Problem-solving methods recorded by the video tape were evaluated and documented in a separate table for each participant. Relationships between each participant's computer anxiety, cognitive style, and method of problem-solving were documented in tables and figures in the next section.

FINDINGS

Results

The results were presented as correlations and averages. A figure has been shown for each correlation and the averages have been shown in tables. The results have been divided into sections as they pertain to the three initial hypotheses.

Relationship between Computer Anxiety Level and Cognitive Style

The average computer anxiety level for each of the MBTI preferences is shown in Table 1. The average anxiety level for Extraversion preference (52) was slightly lower than the average for Introversion preference (60). The average anxiety level for Sensing preference (59) was slightly higher than the average for INtuition preference (52). Level of anxiety for Thinking preference (57) was higher than that of Feeling preference (46). Judging preference (60) anxiety level was higher than Perceiving preference (50) anxiety. Extraversion (60) and Judging (60) preferences showed the highest average anxiety level, while Feeling preference (46) showed the lowest. The average computer anxiety level for a sample of 545 college students was 62.33 with a standard deviation of 17.76 (Simonson, et al. 247). The lowest possible anxiety score was 26 and the highest possible score was 156.

Table 1.

Average Computer Anxiety Level for Each MBTI Preference

MBTI Preference	Number of Participants	Average Computer Anxiety Level
Extraversion	15	52
Introversion	8	60
Sensing	8	59
iNtuition	15	52
Thinking	18	57
Feeling	5	46
Judging	10	60
Perceiving	13	50

The correlation between computer anxiety level and Extraversion/Introversion preferences is shown in Figure 2. There was a .20 (p=.37) correlation between anxiety level and Extraversion/Introversion preference. Level of computer anxiety decreased as the preference for Extraversion increased. Level of computer anxiety increased as the preference for Introversion increased.

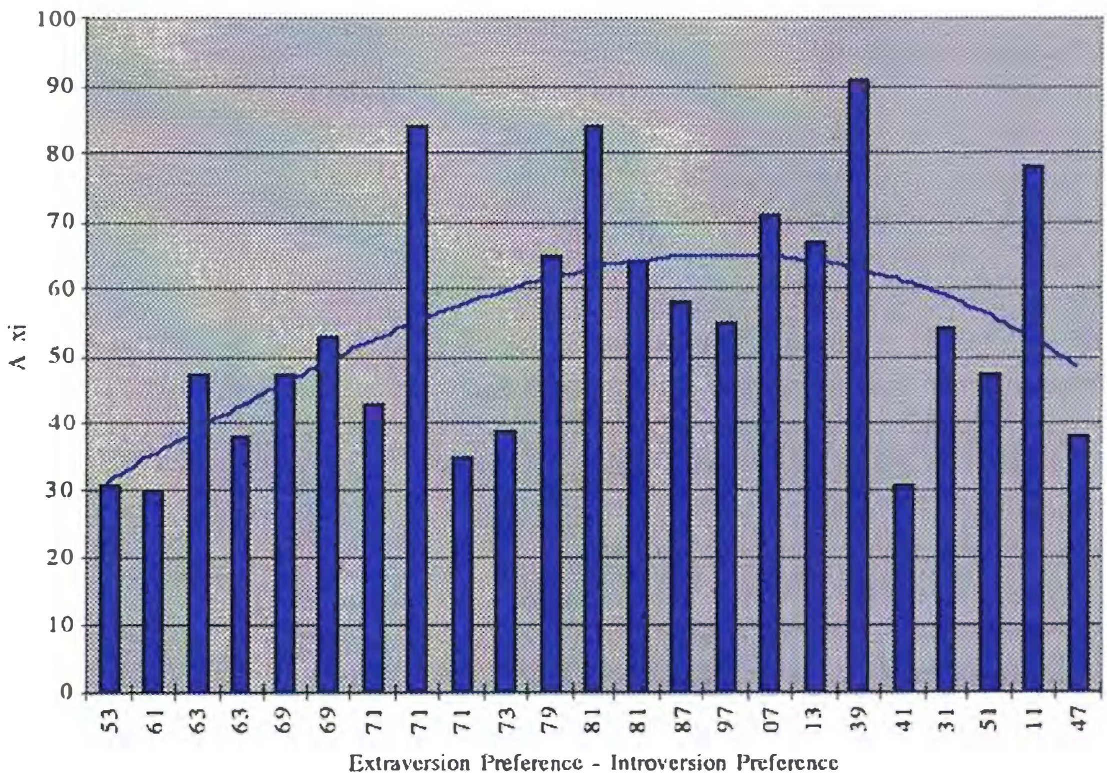


Figure 2. Correlation between Computer Anxiety Level and Extraversion/Introversion Preference

The correlation between computer anxiety level and Sensing/iNtuition preferences is shown in Figure 3. There was a -.31 (p=.15) correlation between anxiety level and Sensing/iNtuition preference. Level of computer anxiety increased as the preference for Sensing increased. Level of computer anxiety decreased as the preference for iNtuition increased.

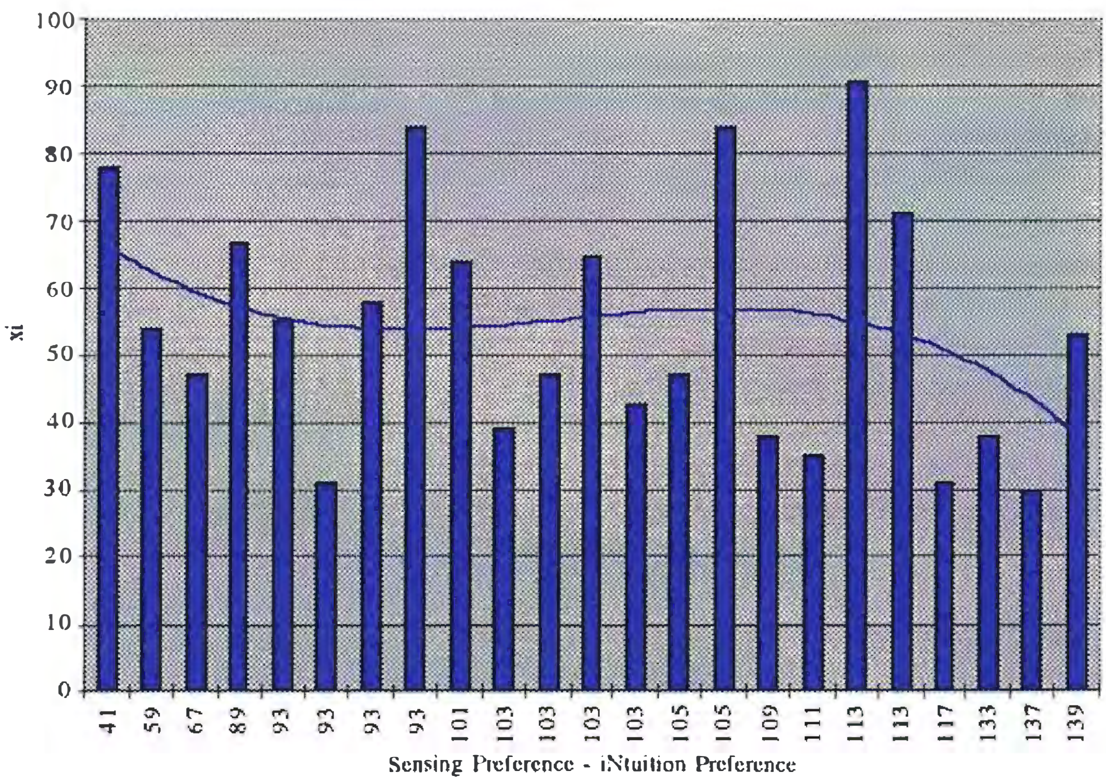


Figure 3. Correlation between Computer Anxiety Level and Sensing/iNtuition Preference

The correlation between computer anxiety level and Thinking/Feeling preferences is shown in Figure 4. The correlation between anxiety level and Thinking preference was -.27 (p=.21). Therefore, the level of computer anxiety increased as the preference for Thinking increased. Conversely, level of computer anxiety decreased as the preference for Feeling increased.

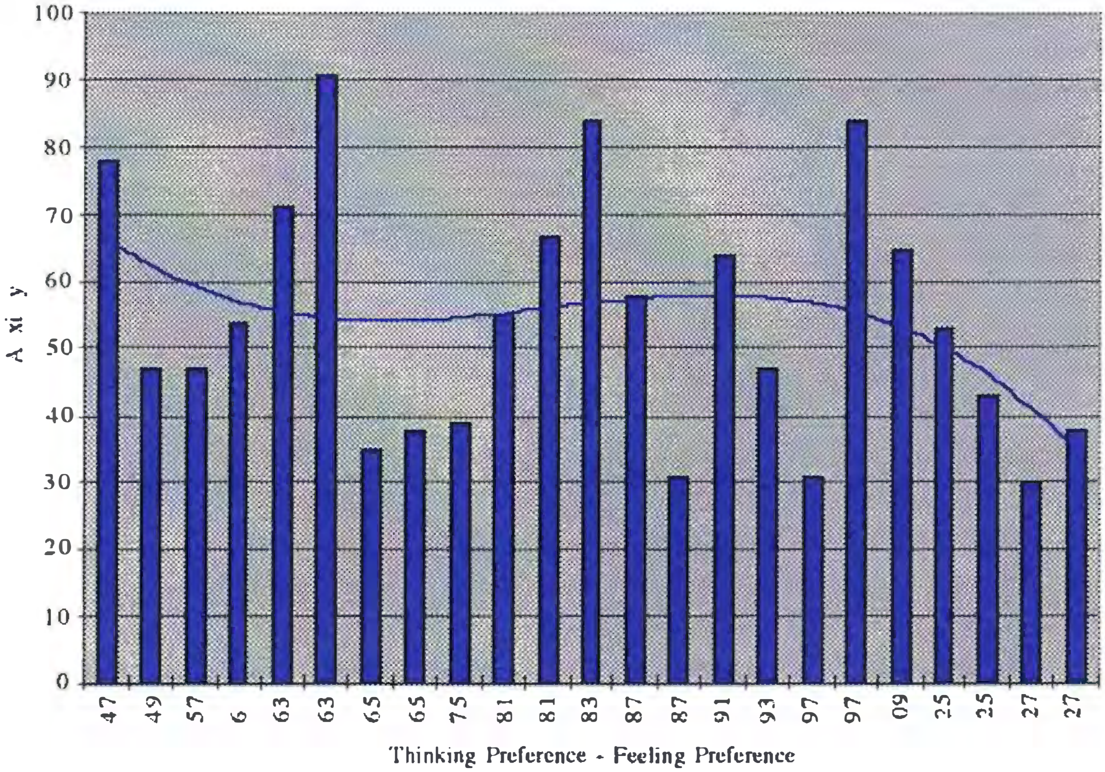


Figure 4. Correlation between Computer Anxiety Level and Thinking/Feeling Preference

The correlation between computer anxiety level and Judging/Perceiving preferences is shown in Figure 5. The correlation between anxiety level and Judging preference was -.31 (p=.15). Level of computer anxiety increased as the preference for Judging increased. Level of computer anxiety decreased as the preference for Perceiving increased.

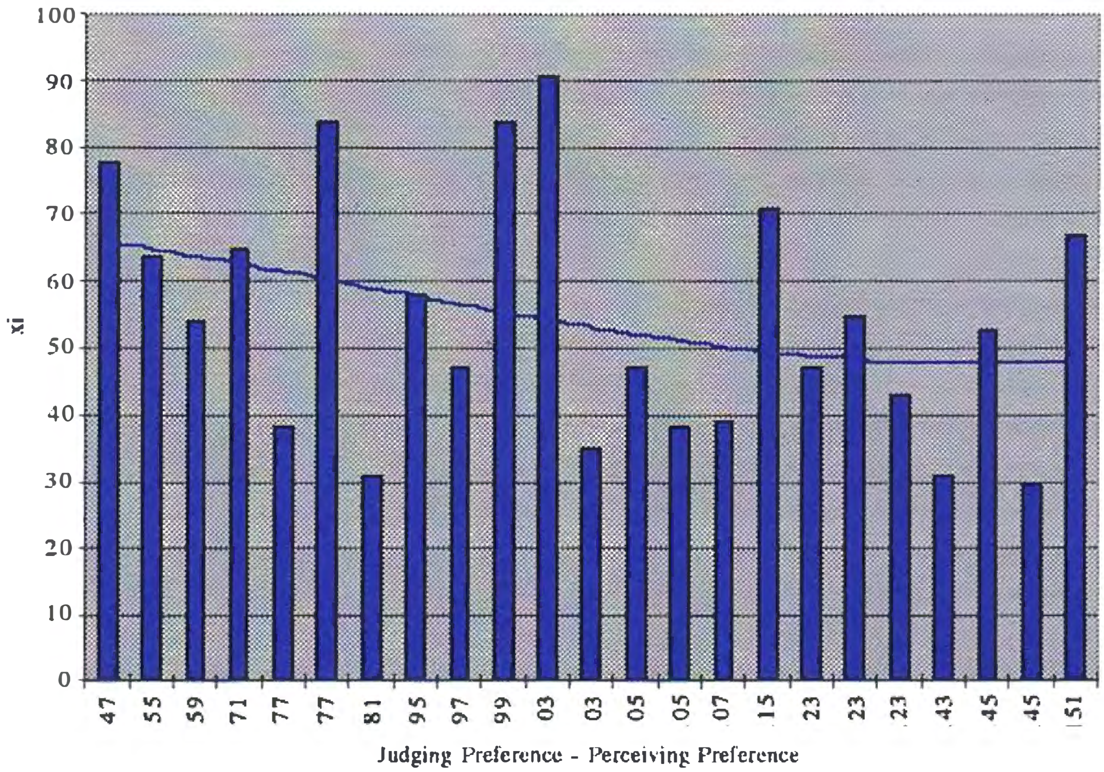


Figure 5. Correlation between Computer Anxiety Level and Judging/Perceiving Preference

Relationship between Computer Anxiety Level and Method of Problem-solving

The correlation between computer anxiety level and the percent of problem-solving time spent using reading methods is shown in Figure 6. There was a -.10 (p=.68) correlation between anxiety level and percent of time reading. Therefore, the amount of time spent reading decreased as the level of anxiety increased.

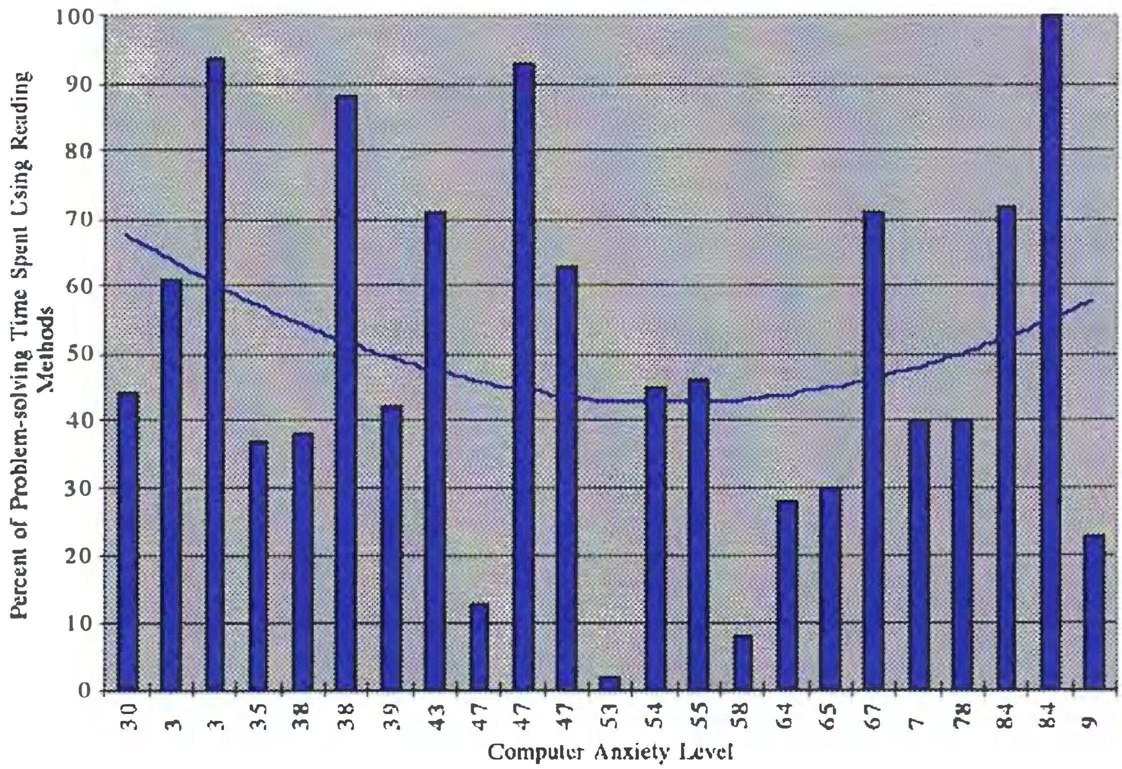


Figure 6. Correlation between Computer Anxiety Level and Using Reading Problem-solving Methods

The correlation between computer anxiety level and the percent of problem-solving time spent using non-reading methods is shown in Figure 7. There was a .04 (p=.85) correlation between anxiety level and percent of time using non-reading methods. Therefore, the amount of time spent using non-reading methods increased slightly as the level of anxiety increased.

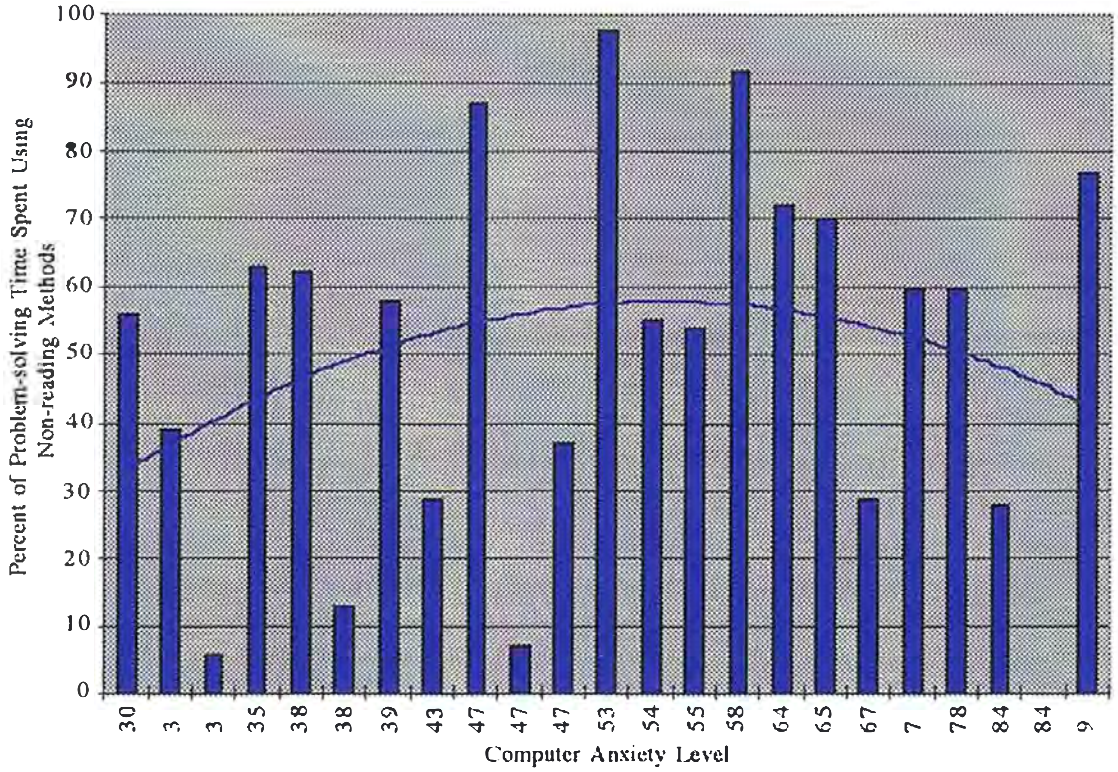


Figure 7. Correlation between Computer Anxiety Level and Using Non-reading Problem-solving Methods

Relationship between Cognitive Style and Method of Problem-solving

The average percent of time spent using reading vs. non-reading problem-solving methods for each MBTI preference is shown in Table 2. The average percent of time spent using reading methods was lower for Extraversion preference (46%) than it was for Introversion preference (58%). Persons with Sensing preferences (52%) averaged a greater percent of problem-solving time reading than those with iNutition preferences (49%). Participants with Thinking preferences (54%) averaged far more time using reading methods than those with Feeling preferences (37%). Similarly, those with Judging preferences (60%) averaged far more time using reading methods than participants with Perceiving preferences (42%). The opposite is true for non-reading methods. The average percent of time spent using non-reading methods was higher for Extraversion preference (54%) than it was for Introversion preference (42%). Persons with iNtuition preferences (51%) averaged a slightly higher percent of problem-solving time using non-reading methods than those with Sensing preferences (48%). Participants with Feeling preferences (63%) averaged far more time using non-reading methods than those with Thinking preferences (47%). Similarly, those with Perceiving preferences (58%) averaged far more time using non-reading methods than participants with Judging preferences (40%).

Table 2.

Relationship between Cognitive Style and Method of Problem-solving

MBTI Preference	Number of Participants	Average Percent of Time Spent Using Reading Problem-solving Methods	Average Percent of Time Spent Using Non-reading Problem-solving Methods
Extraversion	15	46	54
Introversion	8	58	42
Sensing	8	52	48
iNtuition	15	49	51
Thinking	18	54	47
Feeling	5	37	63
Judging	10	60	40
Perceiving	13	42	58

The percent of problem-solving time spent using reading methods versus the percent of time spent using non-reading methods for Extraversion/Introversion preferences is shown in Figure 8. The correlation between Extraversion/Introversion preference and percent of time spent using reading methods was .21 (p=.34). Percent of problem-solving time spent using reading methods decreased as Extraversion preference increased. Percent of problem-solving time spent using reading methods increased as Introversion preference increased. Conversely, the correlation between Extraversion/Introversion preference and percent of time spent using non-reading methods was -.21(p=.34). Percent of problem-solving time spent using non-reading methods increased as Extraversion preference increased. Percent of problem-solving time spent using non-reading methods decreased as Introversion preference increased.

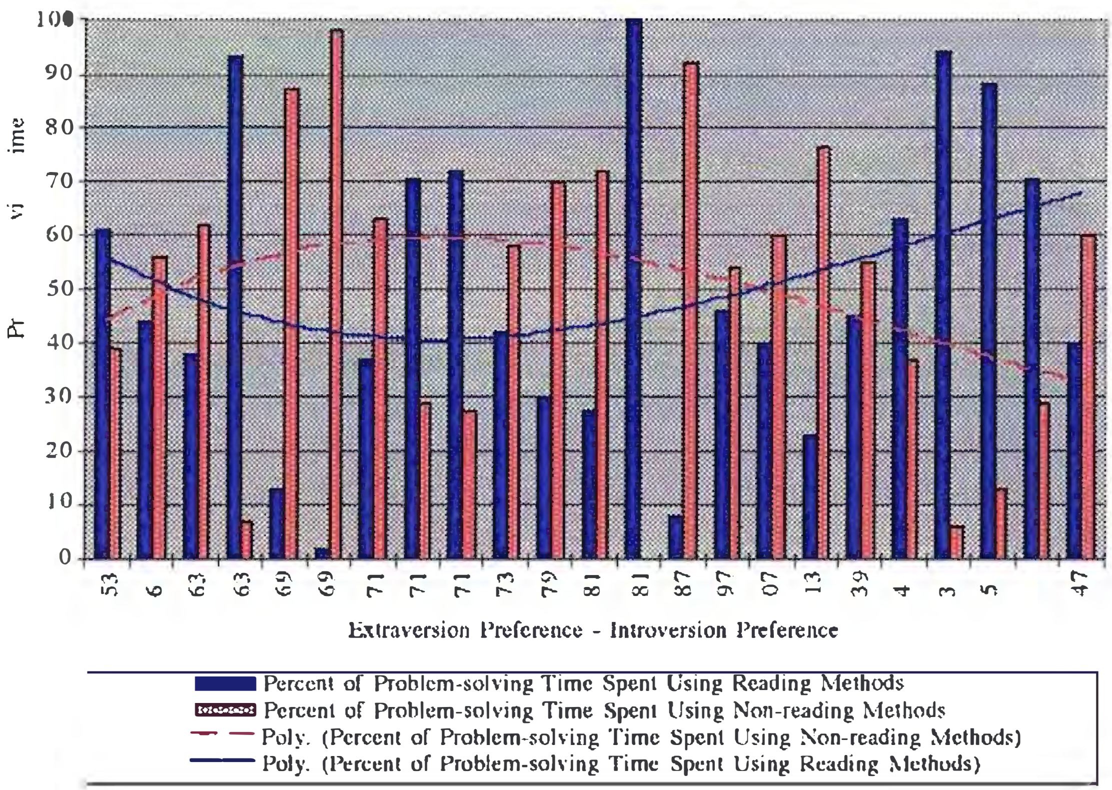


Figure 8. Correlation between Extraversion/Introversion Preference and Problem-solving Methods

The percent of problem-solving time spent using reading methods versus the percent of time spent using non-reading methods for Sensing/iNtuition preferences is shown in Figure 9. The correlation between Sensing/iNtuition preference and percent of time spent using reading methods was .14 (p=.54). Percent of problem-solving time spent using reading methods decreased as Sensing preference increased. Percent of problem-solving time spent using reading methods increased as iNtuition preference increased. Conversely, the correlation between Sensing/iNtuition preference and percent of time spent using non-reading methods was -.13 (p=.54). Percent of problem-solving time spent using non-reading methods increased as Sensing preference increased. Percent of problem-solving time spent using non-reading methods decreased as iNtuition preference increased.

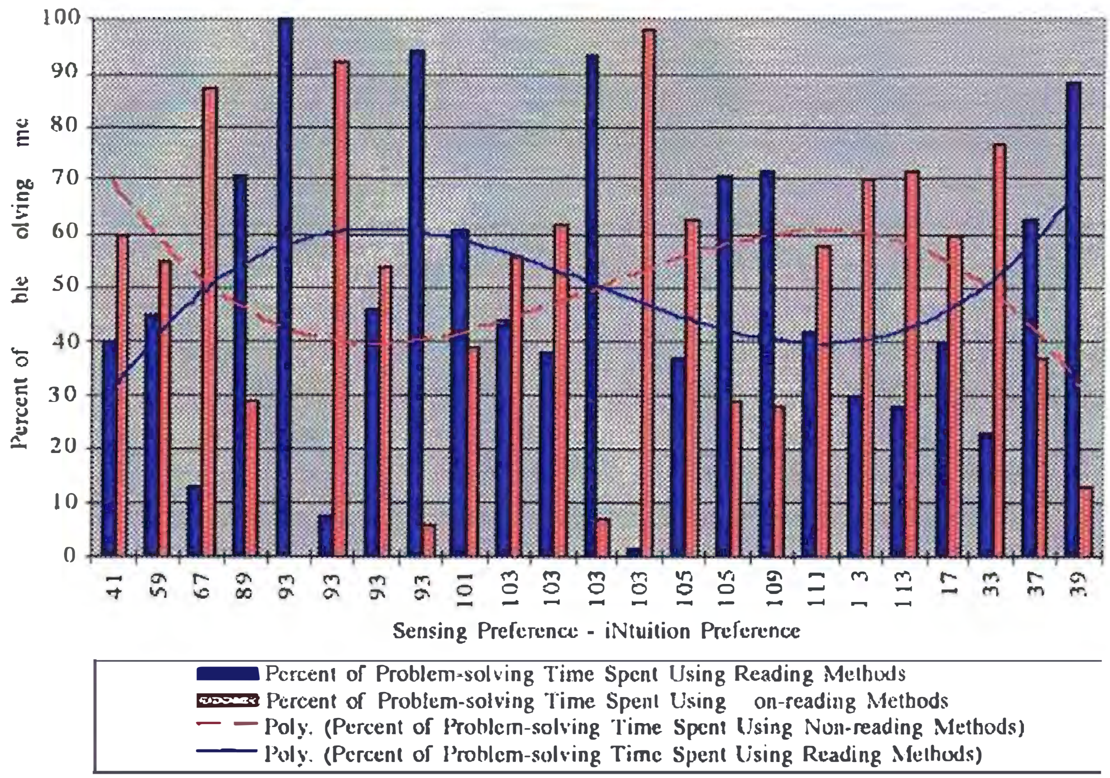


Figure 9. Correlation between Sensing/iNtuition Preference and Problem-solving Methods

The percent of problem-solving time spent using reading methods versus the percent of time spent using non-reading methods for Thinking/Feeling preferences is shown in Figure 10. The correlation between Thinking/Feeling preference and percent of time spent using reading methods was -.01 (p=.95). Percent of problem-solving time spent using reading methods increased as Thinking preference increased. Percent of problem-solving time spent using reading methods decreased slightly as Feeling preference increased. Conversely, the correlation between Thinking/Feeling preference and percent of time spent using non-reading methods was .01 (p=.96). Percent of problem-solving time spent using non-reading methods decreased as Thinking preference increased. Percent of problem-solving time spent using non-reading methods increased slightly as Feeling preference increased.

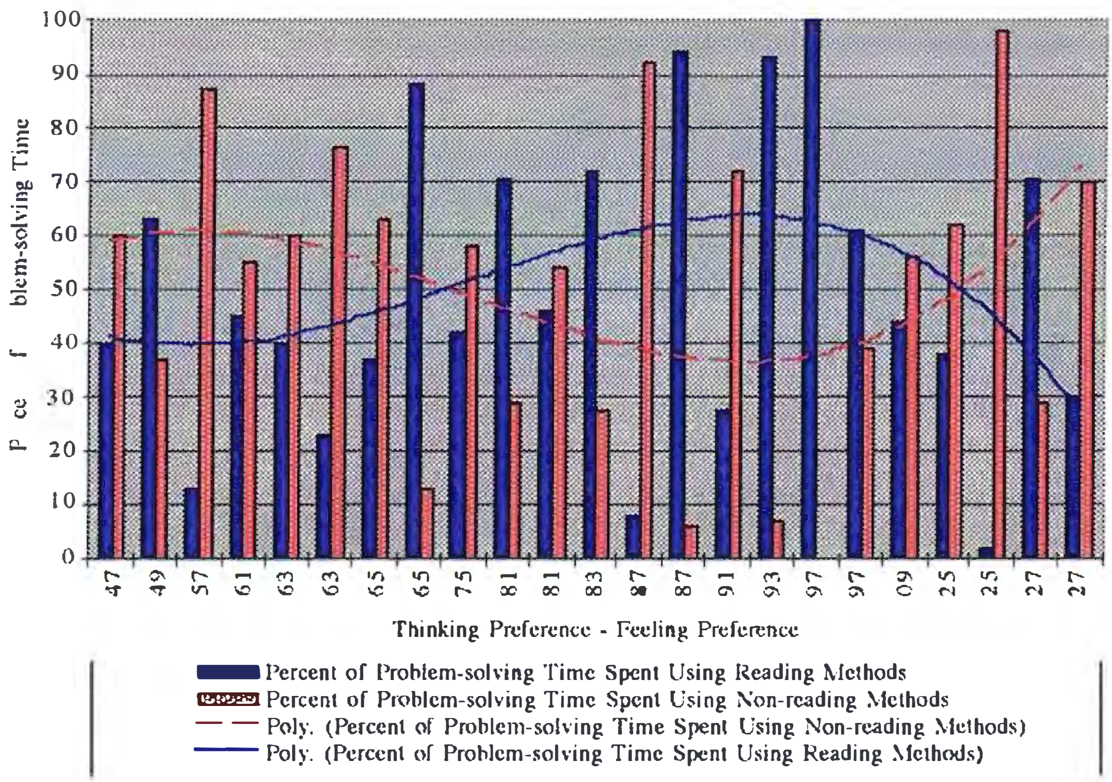


Figure 10. Correlation between Thinking/Feeling Preference and Problem-solving Methods

The percent of problem-solving time spent using reading methods versus the percent of time spent using non-reading methods for Judging/Perceiving preferences is shown in Figure 11. The correlation between Judging/Perceiving preferences and percent of time spent using reading methods was -.07 (p=.75). Percent of problem-solving time spent using reading methods decreased as Judging preference increased. Percent of problem-solving time spent using reading methods increased as Perceiving preference increased. Conversely, the correlation between Judging/Perceiving preference and percent of time spent using non-reading methods was .07 (p=.76). Percent of problem-solving time spent using non-reading methods increased slightly as Judging preference increased. Percent of problem-solving time spent using non-reading methods decreased as Perceiving preference increased.

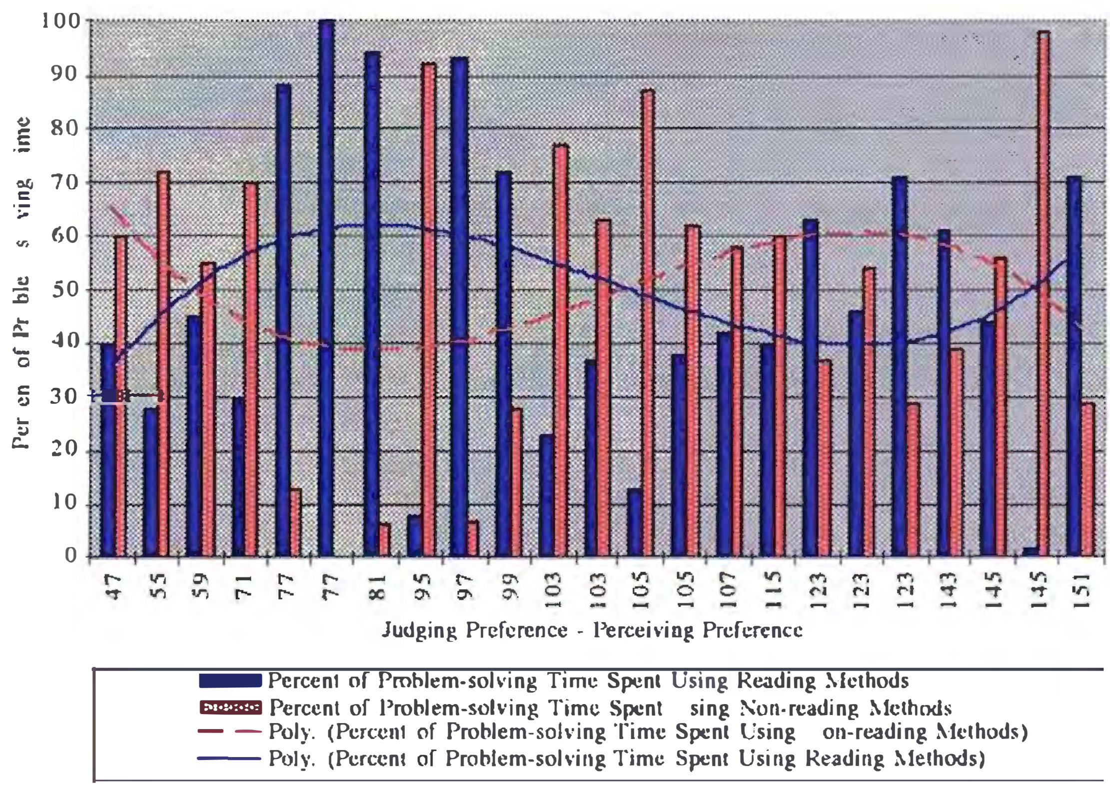


Figure 11. Correlation between Judging/Perceiving Preference and Problem-solving Methods

Relationship between Task Performance and Computer Anxiety Level

The correlation between task performance and level of computer anxiety is shown in Figure 12. The correlation between task performance and anxiety level was .19 (p=.40). Task performance increased slightly as computer anxiety level increased.

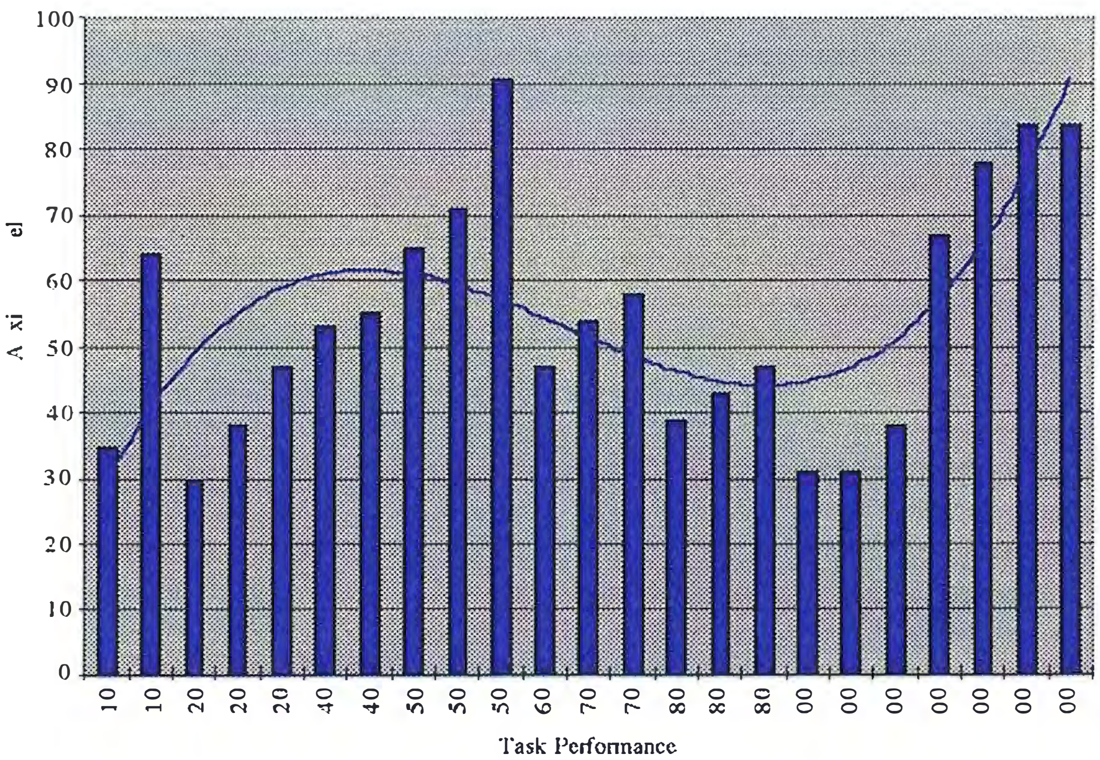


Figure 12. Correlation between Task Performance and Computer Anxiety

Relationship between Task Performance and Cognitive Style

The percent of participants that scored above 50% correct versus the percent that scored 50% or below on the tutorial for each MBTI preference is shown in Figure 13. Less than half of the participants with Extraversion preferences (47%) averaged above 50% on the tutorial while three-quarters of those with Introversion preferences (75%) averaged above 50%. Three-quarters of persons with Sensing preferences (75%) averaged above 50%, less than half of those with iNtuition preferences (47%) averaged above 50%. The percent of participants with Thinking preferences (67%) who averaged above 50% was far above those with Feeling preferences (20%). Similarly, more participants with Judging preferences (80%) averaged above 50% than those with Perceiving preferences (38%).

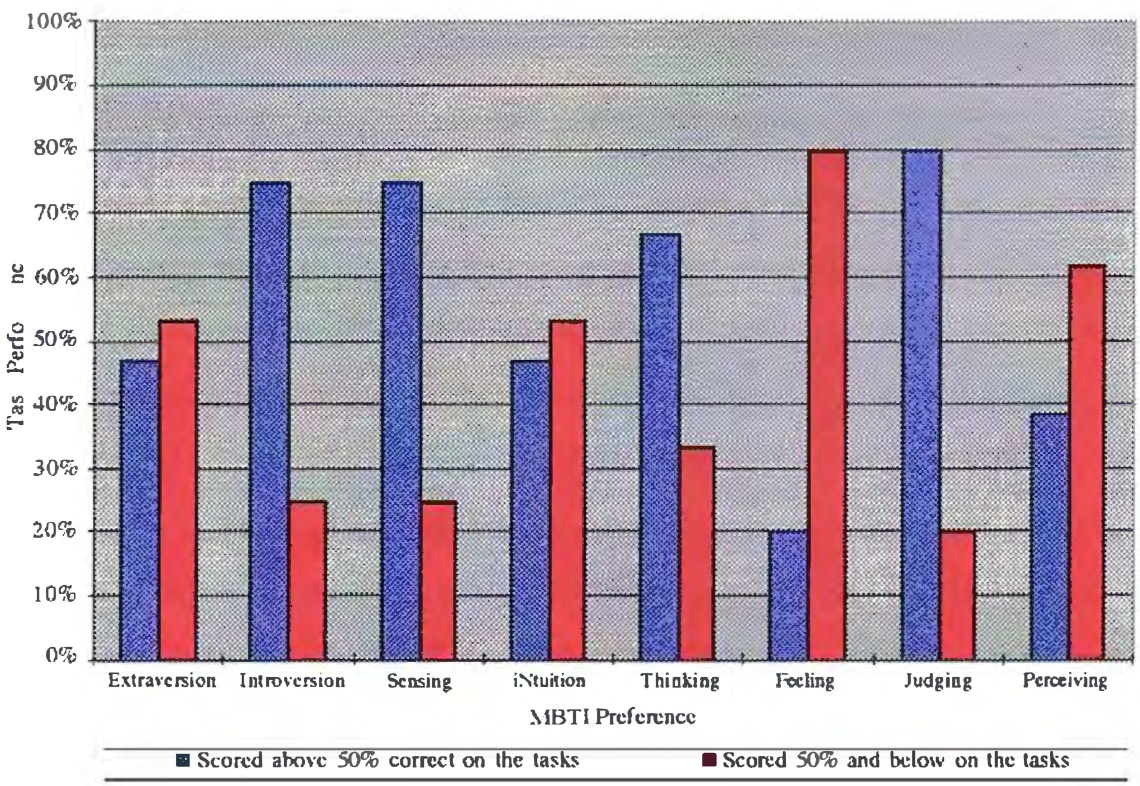


Figure 13. Relationship between Task Performance and Cognitive Style

Discussion

After reviewing the results, the hypotheses were accepted and rejected as follows:

1. There is no relationship between level of computer anxiety and cognitive style, was rejected.
2. There is no relationship between level of computer anxiety and method of problem-solving for a computer-based task, was accepted.
3. There is no relationship between cognitive style and method of problem-solving for a computer-based task, was rejected.

Although correlations were low, the decision to accept or reject hypotheses was made on the basis of results and previous literature. Details of the findings are discussed in the following paragraphs.

Relationship between Participant Demographics and Level of Computer Anxiety, Cognitive Style, Method of Problem-solving, and Task Performance

The only trend present when the demographics were sorted by computer anxiety level was that participants who reported having more computer experience had lower anxiety. When sorted by Myers-Briggs type, it was determined that four of the fifteen participants with Extraversion preference were male and eleven were female. All participants with Introversion preference were male. Females with Introversion preferences were not represented in this study. This possibility was not controlled because the participants were recruited without prior knowledge of their type preferences. This error could be controlled by pre-testing subjects with the MBTI and recruiting an equal number of male and female subjects for each preference. The other types had at least one male and female for each category. No trends were present when the data were sorted by method of problem-solving or task performance.

Number of Participants Exhibiting Each MBTI Preference

All eight preferences were represented by the participants. However, unequal numbers in each category could have caused some bias towards the under-represented preferences. The Thinking/Feeling preference was represented the most unequally. With only five participants representing the Feeling preference, one might want to test more persons in this category before attempting to apply these results.

Relationship between Level of Computer Anxiety and Cognitive Style

The first hypothesis, which states "there is no relationship between level of computer anxiety and cognitive style," was not supported. Although correlations between computer anxiety and cognitive style were low, trends were present. The average level of computer anxiety was lower for participants with Extraversion preference (52%) than it was for those with Introversion preferences (60%). Also, there was a positive correlation (.20 (p=.37)) between Introversion preference and computer anxiety. Together, these measures showed a higher level of computer anxiety being associated with Introversion preference. No comparison was made between Extraversion/Introversion preferences and computer anxiety or ability in the reviewed literature.

Sensing preference (59%) was matched with a higher average level of computer anxiety than iNtuition preference (52%). Similarly, there was a negative correlation between Sensing/iNtuition preferences (-.31 (p=.15)) and level of computer anxiety. A lower level of computer anxiety has been associated with iNtuition preference. These results support those of W. Paul Jones in, "Computer Use and Cognitive Style," where he reports that persons with iNtuition preferences were more likely to purchase or borrow hardware or software.

The average level of computer anxiety was shown to be substantially higher for participants with Thinking preference (57%) than those with Feeling preference (46%).

Additionally, there was a negative correlation (-.27 (p=.21)) between Thinking/Feeling preferences and computer anxiety. Participants with Feeling preferences were shown to have a lower level of computer anxiety. These results are contradictory to Jones's. He reported that persons with Thinking preference were more likely to experiment with a new software application.

Participants with Judging preference (60%) demonstrated a higher average level of computer anxiety than those with Perceiving preference (50%). Similarly, there was a negative correlation between Judging/Perceiving preference (-.31 (p=.15)) and computer anxiety. Perceiving preference was shown to be associated with lower levels of computer anxiety. The relationship between Judging/Perceiving preferences and computer anxiety or ability was not addressed in the reviewed literature.

Relationship between Level of Computer Anxiety and Method of Problem-solving

The second hypothesis, which states "there is no relationship between level of computer anxiety and method of problem-solving for a computer-based task," was supported. The correlations between level of computer anxiety and the two distinct methods of problem-solving, reading (-.10 (p=.68)) and non-reading methods (.04 (p=.85)), were very low. Also, no literature was found which addressed this topic.

Relationship between Cognitive Style and Method of Problem-solving

The third hypothesis, which states "there is no relationship between cognitive style and method of problem-solving for a computer-based task," was not supported. The correlations were low but some trends were supported by previous literature. Participants with Extraversion preferences (46%) averaged less of their problem-solving time using reading methods. There was a positive correlation (.21 (p=.34)) between Extraversion/Introversion preference and use of reading methods. Participants with

Introversion preferences demonstrated a higher tendency towards the use of reading methods. The same correlation coefficient was reported by Myers when testing 236 Wesleyan students on the Davis Reading Test. A correlation coefficient of .21 (p<.01) was reported for the Extraversion/Introversion preference (Myers and McCaulley).

The data collected for Sensing/iNtuition preferences conflicts. Participants with iNtuition preference (49%) averaged a slightly lower percent of problem-solving time reading than those with Sensing preference (52%). However, the correlation was positive (.14 (p=.54)) and percent of problem-solving time spent reading increased with iNtuition preference. The second finding is consistent with Myers's reading level results from the Davis Reading Test. The reported correlation coefficient for Sensing/iNtuition preferences was .34 (p<.01) (Myers and McCaulley). The reading level increased with iNtuition preference. Myers and McCaulley allude to varying of differences between Sensing and iNtuition preferences:

> The size of predicted differences between sensing and iNtuitive types in reading varies with the homogeneity of the sample, but the data are consistent and pose important issues for educators. Since the majority of the general population are sensing types and most learning activities require reading, the failure to learn good reading skills in the early school years has significant implications in school achievement, disruptive behavior, and school dropouts (Myers and McCaulley).

Participants with Thinking preference (54%) averaged a higher amount of problem-solving time using reading methods than those with Feeling preference (37%). Similarly, a negative correlation (-.01 (p=.95)) was reported between Thinking/Feeling preference and use of reading methods. This finding is also consistent with Myers's correlation coefficient of -.04 for reading level. Reading level decreased with Feeling preference.

The average percent of problem-solving time spent reading was higher for participants with Judging preference (60%) than for those with Perceiving preference (42%). There was a negative correlation (-.07 (p=.75)) between Judging/Perceiving preference and use of reading methods. This conflicts with Myers's correlation coefficient for reading level of Judging/Perceiving preference which was reported to be .14.

Relationship between Task Performance and Cognitive Style

There was no hypothesis made about the relationship between task performance and cognitive style. The results were documented in order to make a comparison between these findings and previous literature about the relationship between cognitive style and computer ability. Less than half of the participants with Extraversion preferences (47%) averaged above 50% on the tutorial while three-quarters of those with Introversion preferences (75%) averaged above 50%. Insignificant findings were cited in literature comparing these preferences to computer ability (Bishop-Clark and Wheeler 358-370). Three-quarters of persons with Sensing preferences (75%) averaged above 50%, less than half of those with iNtuition preferences (47%) averaged above 50%. This finding is consistent with previous literature where students with Sensing preferences were found to perform better on programming assignments than students with iNtuition preferences (Bishop-Clark and Wheeler 358-370). The percent of participants with Thinking preferences (67%) who averaged above 50% was far above those with Feeling preferences (20%). However, in the reviewed literature, the relationship between Thinking/Feeling preferences and computer programming ability was found to be insignificant (Bishop-Clark and Wheeler 358-370). More participants with Judging preferences (80%) averaged above 50% than those with Perceiving preferences (38%). This is consistent with the reported finding that, "'Judging' students achieved higher programming averages than 'Perceptive' students" (Bishop-Clark and Wheeler 358-370).

Summary

The Myers-Briggs Type Indicator has been used to rank participants along four continuous dimensions; Extraversion/Introversion preference, Sensing/iNtuition preference, Thinking/Feeling preference, and Judging/Perceiving preference. Along each of the dimensions, one of the preferences had significantly better performance completing the tutorial. The preferences where more than 65% of the participants scored above 50% correct on the tutorial were Introversion, Sensing, Thinking, and Judging. Figure 14 shows that these preferences demonstrated a higher level of computer anxiety and average percent of problem-solving time spent using reading methods. Conversely, less than fifty percent of Extraversion, iNtuition, Feeling, and Perceiving preferences scored above 50% on the tutorial. These preferences also show a lower average level of computer anxiety and higher percent of problem-solving time using non-reading methods.

The relationship between individual differences in computer anxiety, cognitive style, and method of problem-solving was clearly demonstrated when comparing the Judging and Feeling preferences. Judging preference, which was associated with the highest percentage (80%) of participants scoring above 50% on the tutorial, also averaged the greatest percent of problem-solving time spent using reading methods. Inversely, Feeling preference is associated with the lowest percentage of participants scoring above 50% on the tutorial and the highest percent of problem-solving time spent using non-reading methods. Participants of each preference demonstrated a level of task performance depending on their method of problem-solving. Based on these results, computer interfaces should be designed to assist both reading and non-reading problem-solving methods. Recommendations for achieving this goal will be set forth in the next section.

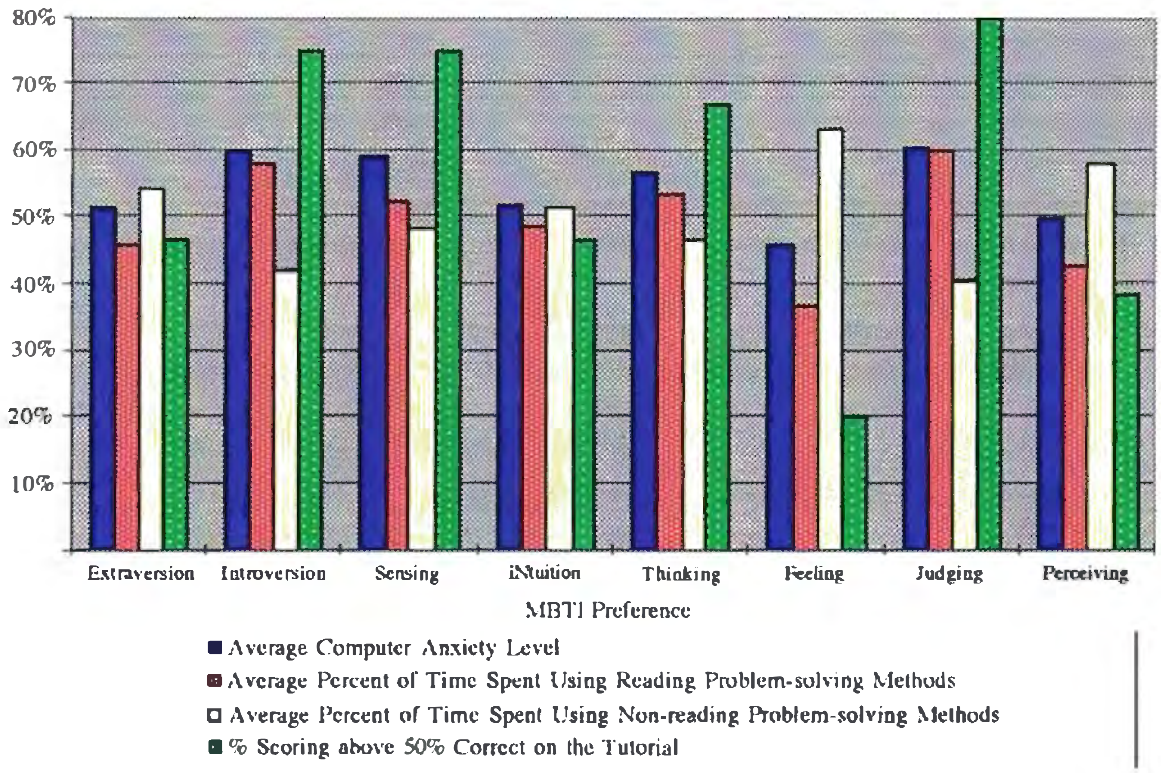


Figure 14. Relationship between Computer Anxiety Level, Method of Problem-solving, and Task Performance for Each MBTI Preference

CONCLUSIONS

Summary

Although correlations were weak, trends were present. Participants with Introversion, Sensing, Thinking, and Judging preferences demonstrated a higher average level of computer anxiety. Conversely, participants with Extraversion, iNtuition, Feeling, and Perceiving preferences had a lower average level of computer anxiety. Remarkably, participants with Introversion, Sensing, Thinking, and Judging preferences also averaged higher scores on task completion despite their higher computer anxiety level. Participants with these preferences averaged a higher percent of problem-solving time using reading methods. Conversely, participants with Extraversion, iNtuition, Feeling, and Perceiving preferences averaged lower scores on the tutorial and higher percent of time using non-reading problem-solving methods. Recommendations were made based on the finding that participants with certain preferences read the manual less, which resulted in poorer performance on the tutorial. The recommendations were aimed at bringing small amounts of text to the computer screen in order to provide hints needed by the types of participants who did not read printed manuals. All recommendations were deliberately general so that they could be applied to other situations. The changes were demonstrated using the current Infini-D computer interface.

Recommendations

The results showed that participants who used certain styles of problem-solving methods did not read the manuals provided. Instead, they clicked around the screen randomly looking for hints. In this research, persons who used these types of problem-solving had a lower success rate when completing the tutorial. Additionally, these users became frustrated and verbalized feelings of failure. The researcher made the following recommendations in an attempt to bring small amounts of text to the computer screen. This would provide hints needed by the participant preferences who did not read printed manuals. The researcher made these recommendations deliberately general so that they could be applied to other situations. The researcher's recommendations and specific events that highlighted the need are listed below.

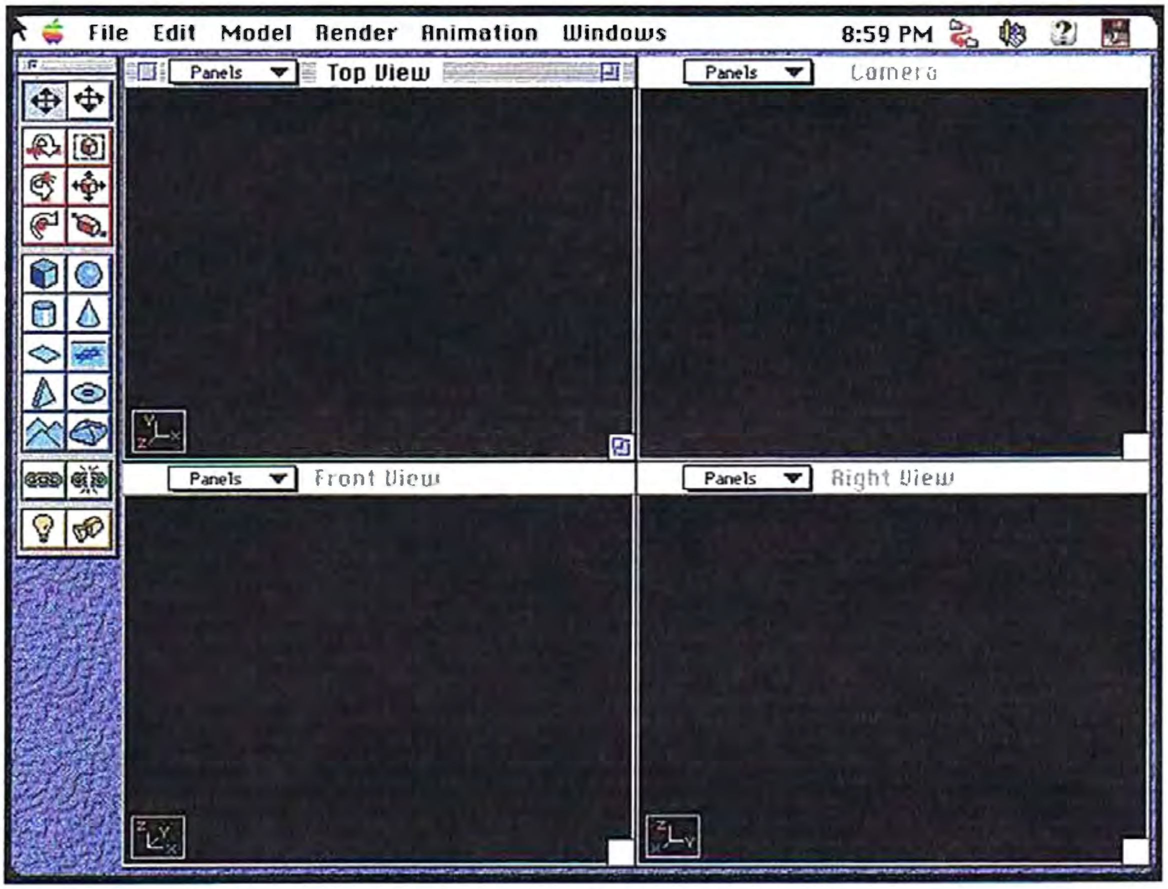


Figure 15. The Original Interface

1. Only provide double-click options in the icon menu. Do not have additional options available when double-clicking in the work space.

The researcher suggested that having additional options available when double-clicking on a tool in the tool box would have worked. However, when frustrated users were clicking around the work space, they invoked new options by mistake. Participant 5 (ENFJ) double-clicked on his table top and encountered the "Primitive" dialogue shown in Figure 16. He mistakenly changed his primitive cube to a cylinder and ended up with a round table top. He could not figure out how he had invoked the dialogue in the first place and was forced to accept the change.

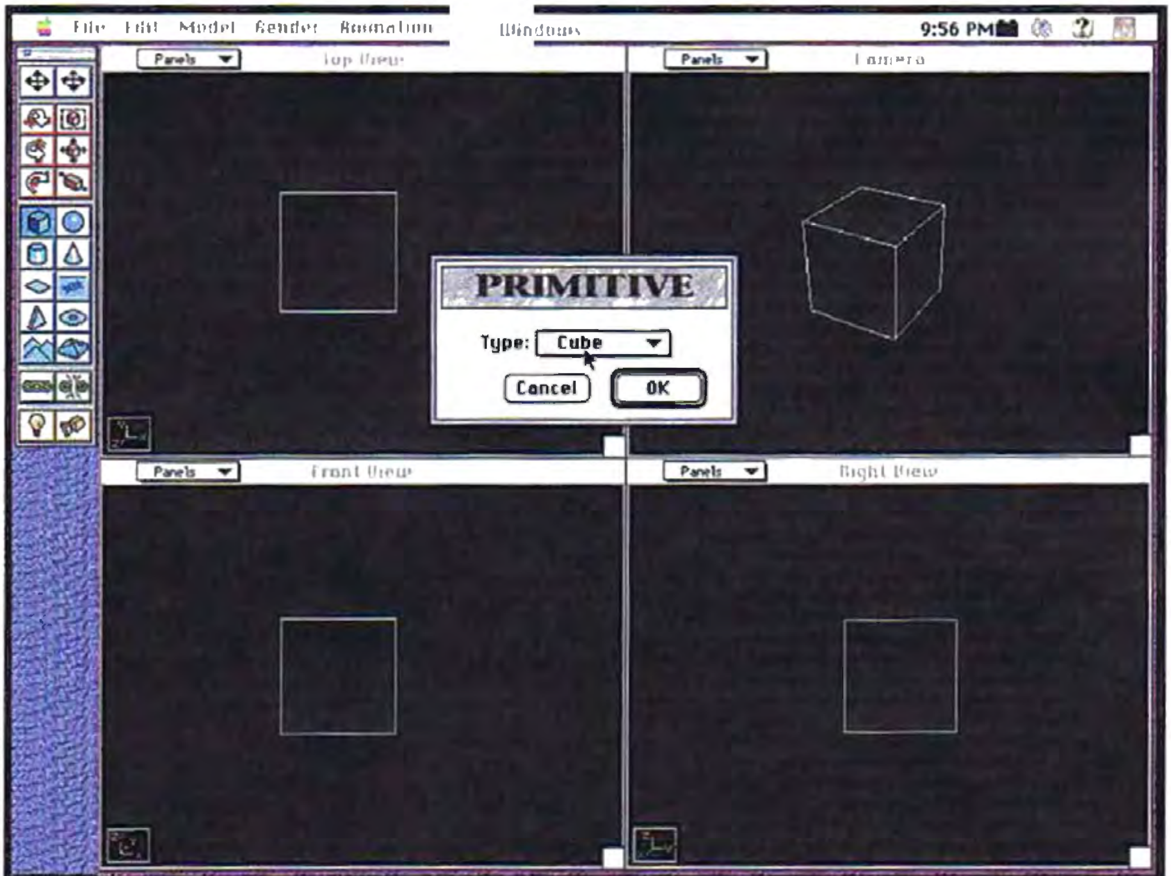


Figure 16. First Recommendation - Do Not Have Dialogue Boxes Invoked When Double-clicking in the Work Space

2. Have the cursor labeled as to which function or option is selected.

When attempting to lock the table legs, many participants forgot which tool was selected. They were trying to select an object with the locking tool still selected. This caused the computer to give an audible error message. They concentrated on the audible message and did not check to see which tool was selected. The researcher suggested that the cursor should have had a default setting for a cursor label. This would have continually reminded users which tool was selected as they moved around the screen. The researcher maintained that the cursor also should have had an "off" setting for advanced users who would be working on complex models. In Figure 17, the "cube tool" is selected and the words "draw cube" appear next to the cursor.

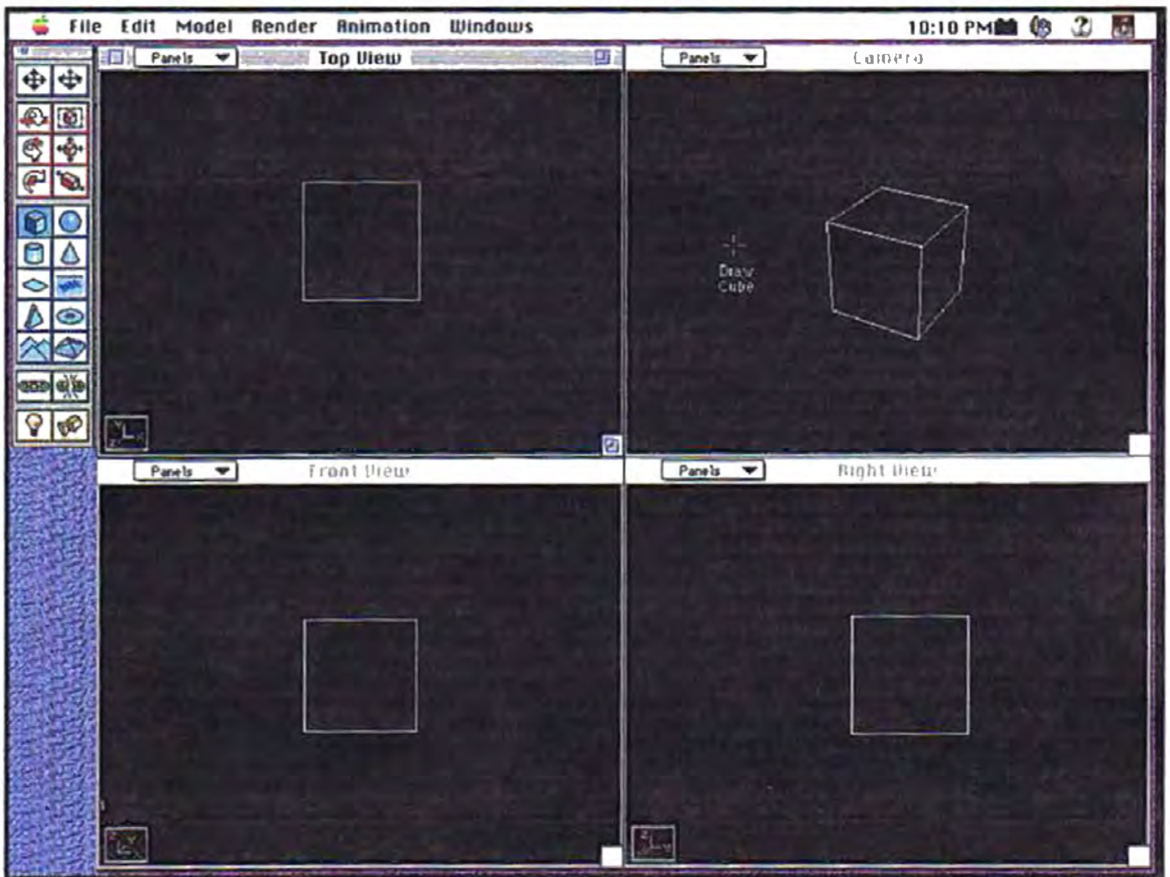


Figure 17. Second Recommendation - Labeled Cursor

3. The cursor label should change color when it is passed over screen items that can be edited in the selected function.

Many of the participants attempted to select the cube while the cube tool was still selected. The cube tool allowed users to draw multiple cubes and, therefore, continued to draw cubes. The user had to select the "vertical plane tool" and then select the cube in order to delete it. The researcher maintained that if the cursor had changed its color to green when it passed over an object that it could modify, then the cube tool never would have changed color. This would have indicated that the cube could not be altered by the cube tool. This recommendation is consistent with those in A Guide to Usability: Human Factors in Computing where it was suggested to use a color that stands out from the screen when highlighting (Preece 70-77). The change is shown in Figure 18.

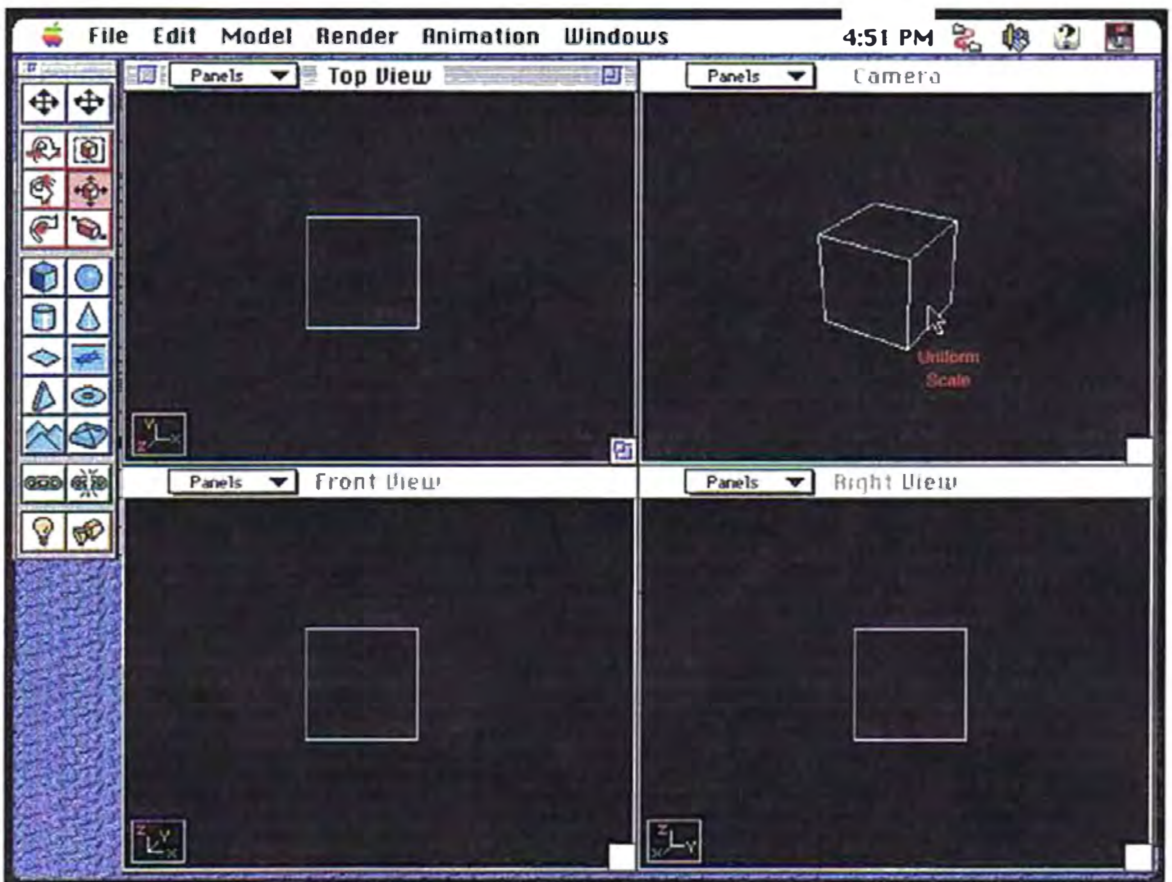


Figure 18. Third Recommendation - Cursor Change

4. Always provide a status bar, which lists the selected tool, option, or function in progress.

The researcher maintained that the icons did not provide enough information as to the function of the tool. Participants verbalized their confusion and often guessed at which icon to use. Only after attempting to use the tool did some participants realize its function. The status bar would have provided information to the user while making selections in the tool box. It would also have provided information in the work space if the cursor label was turned off. This addition of the status bar is shown in Figure 19.

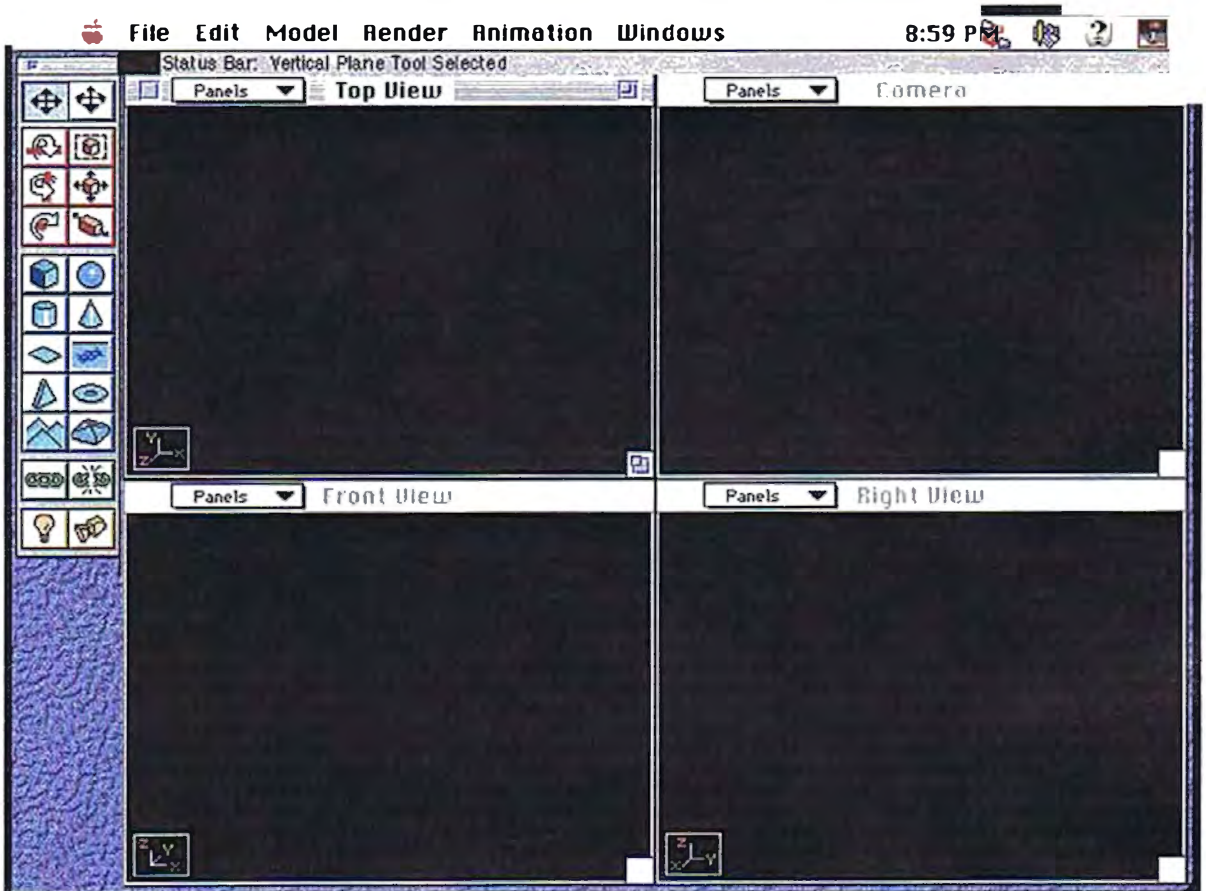


Figure 19. Fourth Recommendation - Status Bar

5. Avoid hidden interface options without a label.

The researcher maintained that the "panels" menu did not have a description as to its function and subsequent menus. Some participants selected different settings from the "panels" menu in an attempt to modify their model. They did not realize that the options only affected how the model was viewed in the window. Also, users who did not read the manual might not locate the window options if they needed them. The researcher moved the "panels" choice to the pull down list. The researcher also moved the "window options" description to the top. Finally, the researcher suggests that the background color of the menu change when the window is selected in order to add extra emphasis to the fact that only one window at a time is active. The changes are shown in Figure 20.

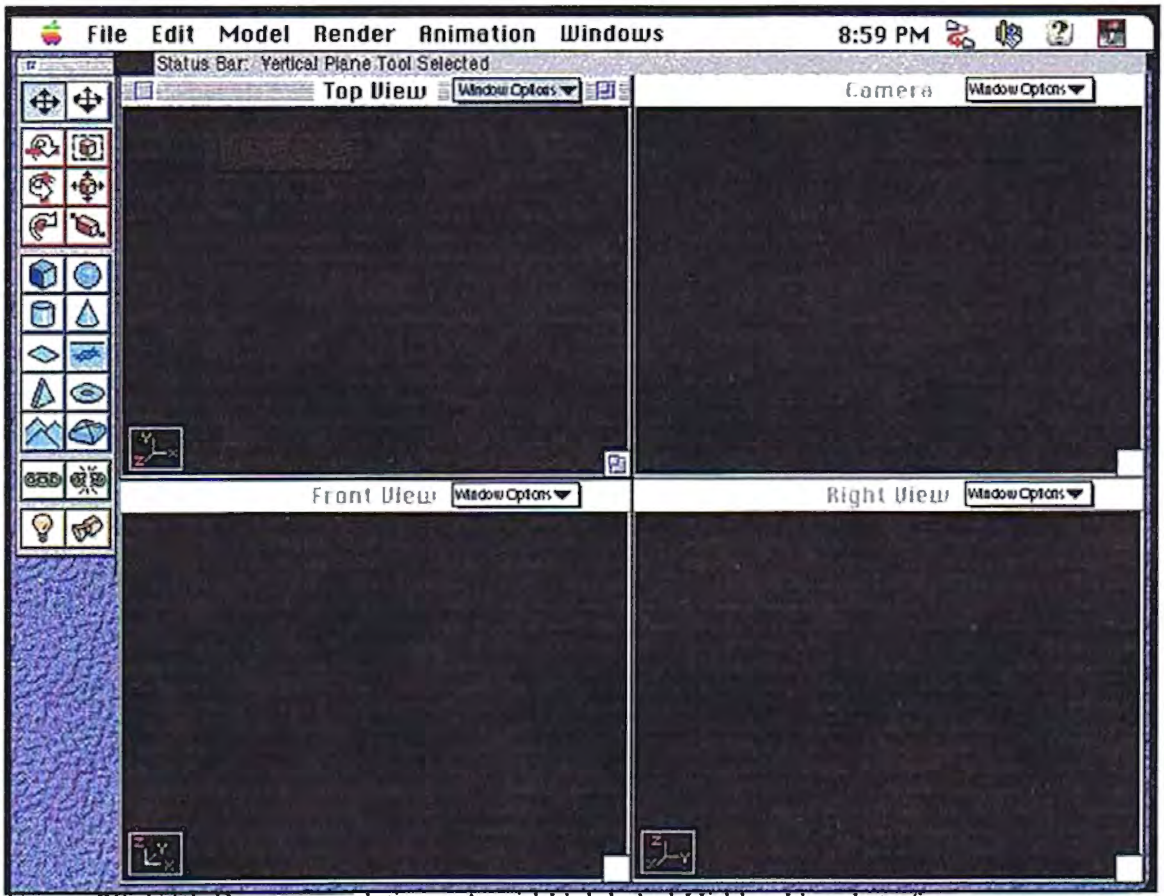


Figure 20. Fifth Recommendation - Avoid Unlabeled Hidden User Interface

6. If an object on the screen has been formatted or transformed, the change should be listed in the status bar when the cursor is passed over the object.

The locking of objects demonstrates the confusion as to whether or not an object had been transformed. No participants could tell if the lock was successful unless they moved the object. Once they moved the object that was unlocked, it was difficult to return all components to their original positions. The researcher suggests that text describing the transformation be displayed in the status bar. The cursor is green because it can modify the objects that it is passing over.

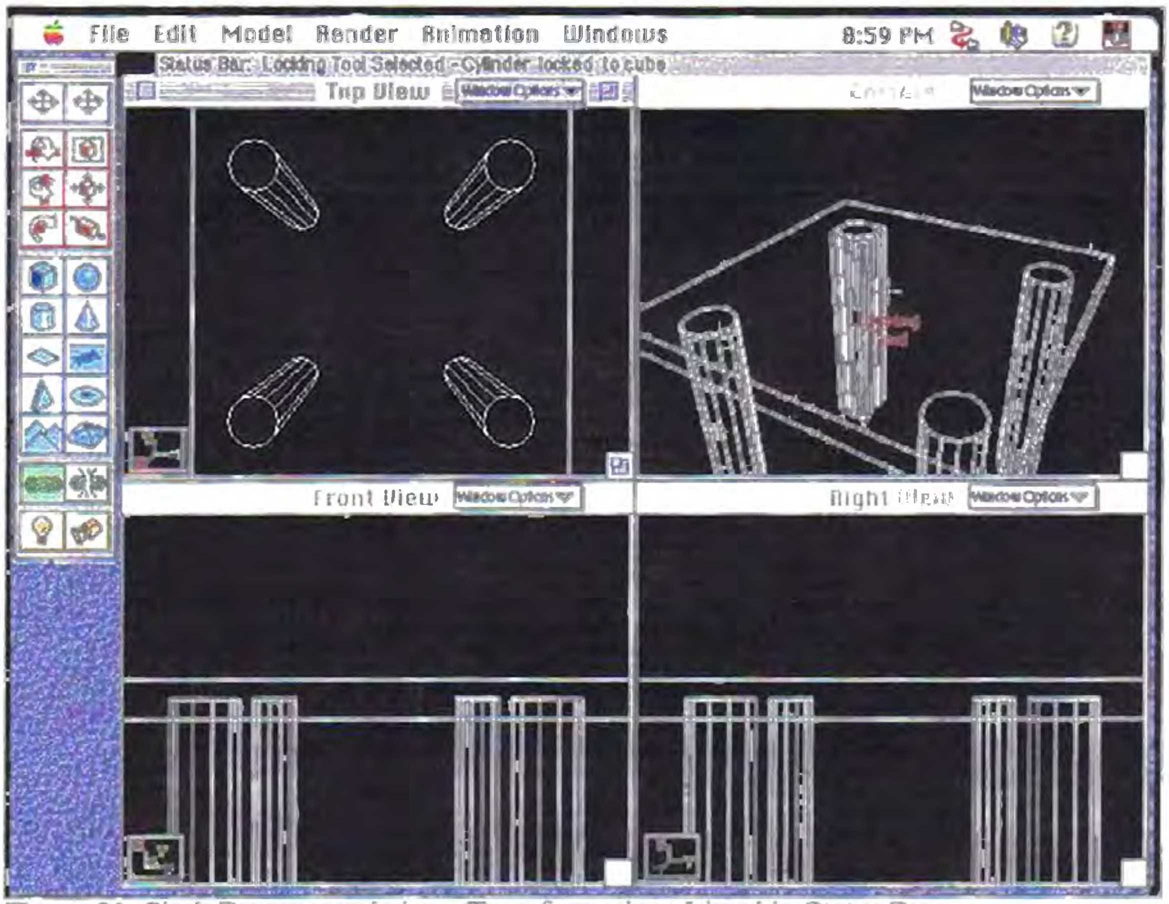


Figure 21. Sixth Recommendation Transformations Listed in Status Bar

7. Icons should be presented in the order of expected use and grouped by function.

Two of the participants attempted to draw cubes with the "Ray Trace Marquee Tool". They chose the ray-tracing tool to draw a cube because it was cube shaped and was situated second from the top in the list of icons. The "Ray Trace Marquee Tool" can only be used after objects are drawn. In the original interface, the order of the icon from top to bottom was: tools to select and move objects; tools to rotate, stretch, and shade objects; tools to draw the primitive objects; locking and unlocking tools; lighting and camera tools. The researcher redesigned the tool box. The order is: tools to draw the primitive objects; tools to select and move objects; tools to rotate, stretch, and shade objects; locking and unlocking tools; lighting and camera tools. These changes are shown in Figure 22.

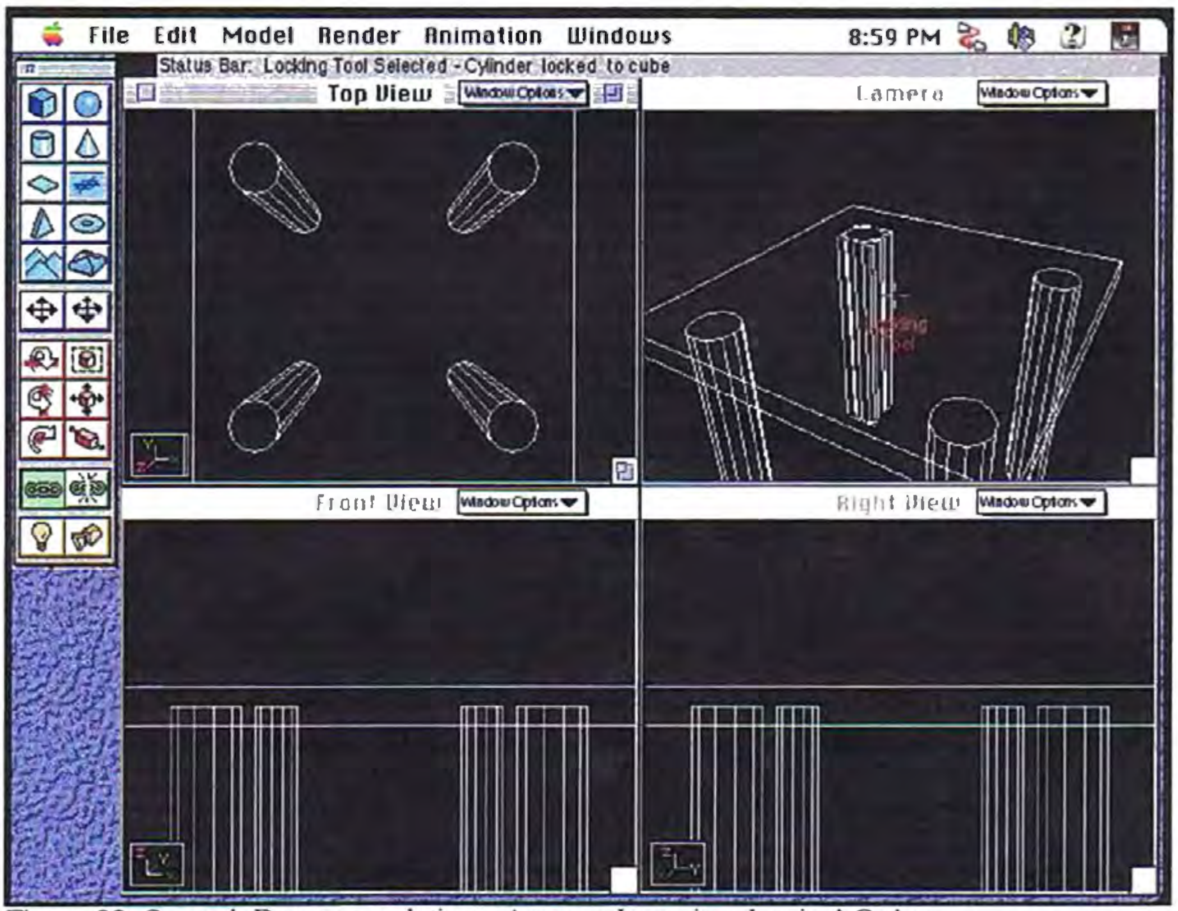


Figure 22. Seventh Recommendation - Arrange Icons in a Logical Order

8. Icons should be easy to differentiate.

Many of the participants needed to look through the beginning of the tutorial repeatedly in order to determine which icon was the "Vertical Plane Tool". The "Horizontal Plane Tool" and "Vertical Plane Tool" were so similar that participants needed to make a direct comparison to the directions. The researcher changed the icons so that they are the same icon rotated 90 degrees. The researcher believes that the change should clarify their functions. This recommendation, shown in Figure 23, is consistent with suggestions in A Guide to Usability: Human Factors in Computing (Preece). In the text, it was maintained that "when designing icons it is important to take into account: the context in which they are used, the task domain for which they are used, the nature of the underlying object represented and the extent to which one icon can be discriminated from other icons displayed" (Preece 144).

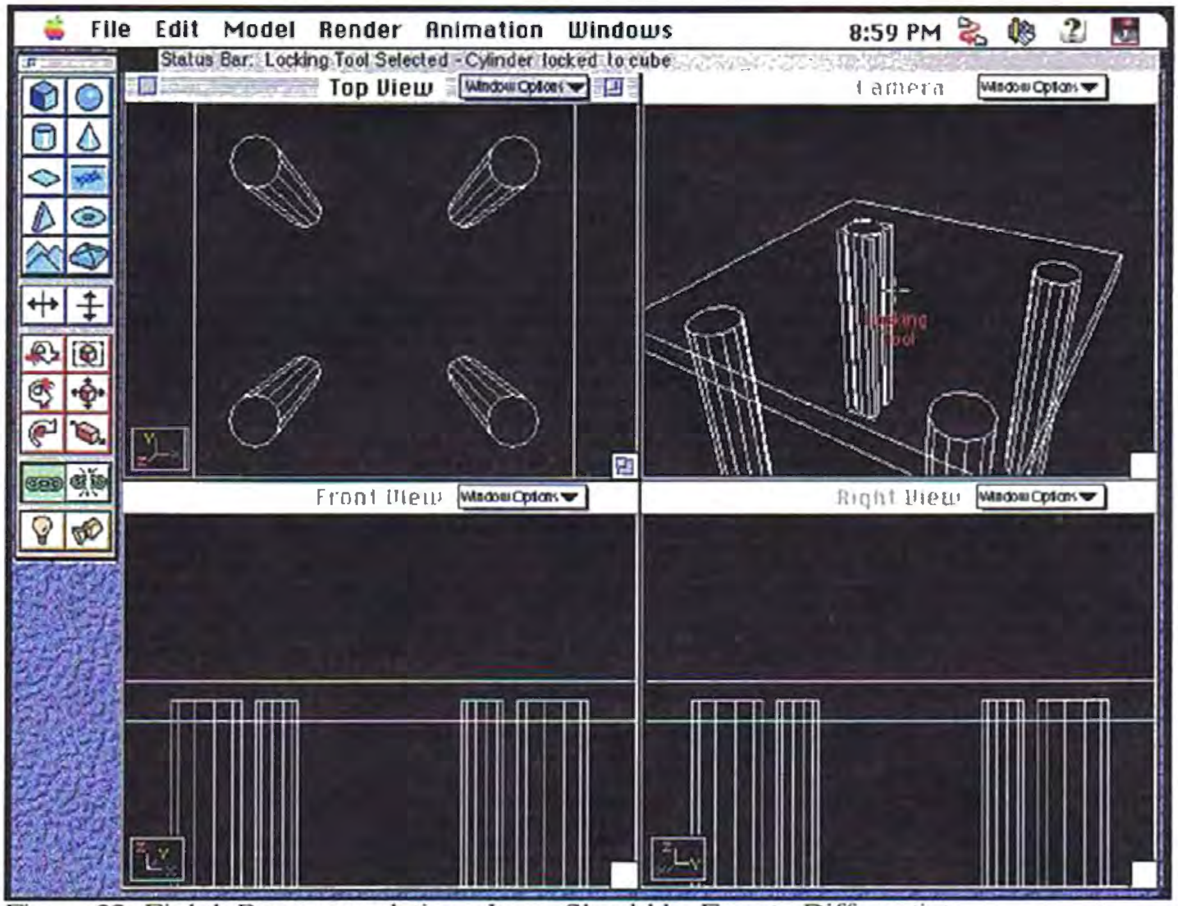


Figure 23. Eighth Recommendation - Icons Should be Easy to Differentiate

9. The "Undo" and "Delete" options should be separate from other functions and easy to recognize in any interface.

Three participants, P2 (ESTJ), P18 (ESTP), and P24 (ENTP), could not figure out how to remove objects and chose to close the file and restart. In order to delete an object, the vertical plane tool had to be selected first, then the cube had to be selected. This would remove the cube from the screen. The researcher maintained that a separate "DELETE" button was needed which can delete objects in one step. She also suggested that the "UNDO" button should have been the same size and in the same location. This would allow the user to return the deleted object should the user delete the wrong item. The researcher capitalized the words in order to draw attention to them. It was suggested in the literature review that, "...conventional upper and lower case text can be read about 13 percent more quickly than all upper case; uppercase characters are most effective for items that need to attract attention."(Preece 144). The change is shown in Figure 24.

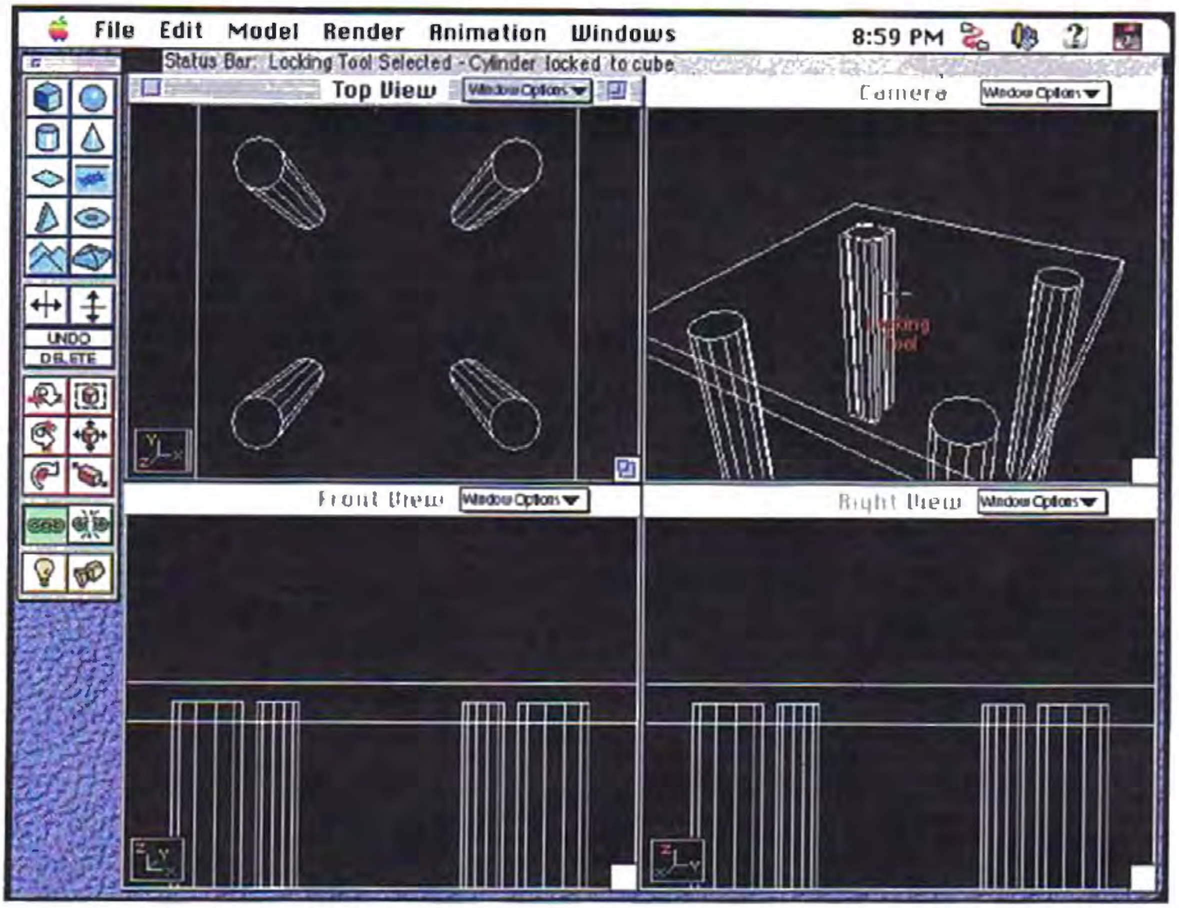


Figure 24. Ninth Recommendation - Undo and Delete Functions Should be Separate from Other Functions

10. On-line help should be available for every software application.

Participant 7 (INTP) would have used on-line help if it had been available. The researcher maintained that on-line help should be available for every software application. Therefore, she suggests that the option "Help" should have been added to the end of the pull-down menus. The modification is shown in Figure 25.

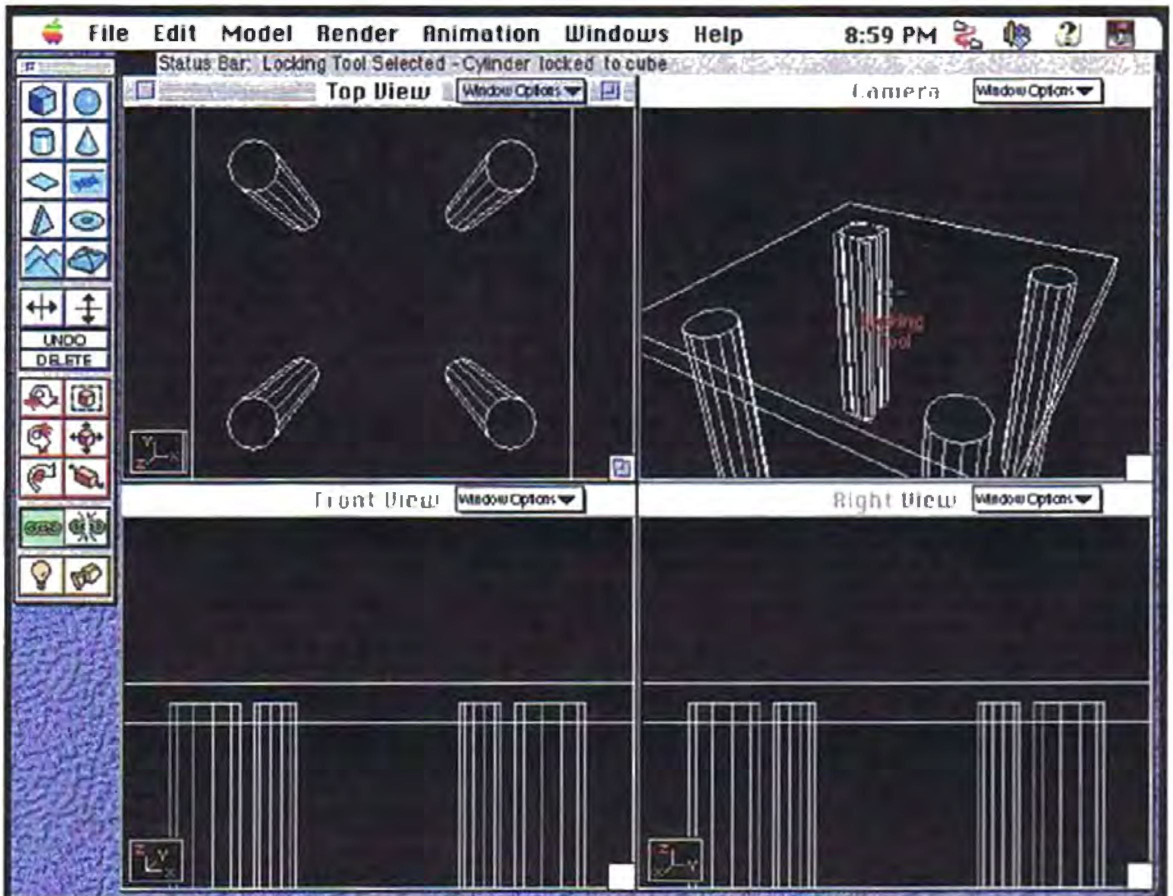


Figure 25. Tenth Recommendation - On-line Help Should be Available for Every Software Application

Implications for Further Research

The findings from this research could be expanded in many ways. The first suggestion is to implement the recommended changes in the interface and repeat the research with the same experimental design. Secondly, the study could be repeated with changes made to the experimental design. One of the weaknesses of this research was that the types were not equally represented. It might be beneficial to repeat the research with equal numbers of males and females for each of the eight Myers-Briggs preferences. Thirdly, this research could be repeated with the tutorial transformed into an on-line document. The research could be repeated with the same design to determine if persons with varied preferences respond differently to on-line instructions.

Finally, a perfect correlation was found between task performance and method of problem-solving. The correlation between task performance and percent of problem-solving time spent using reading methods is shown in Figure 26. There was a correlation of one between task performance and use of reading problem-solving methods. Task performance increased as use of reading problem-solving methods increased.

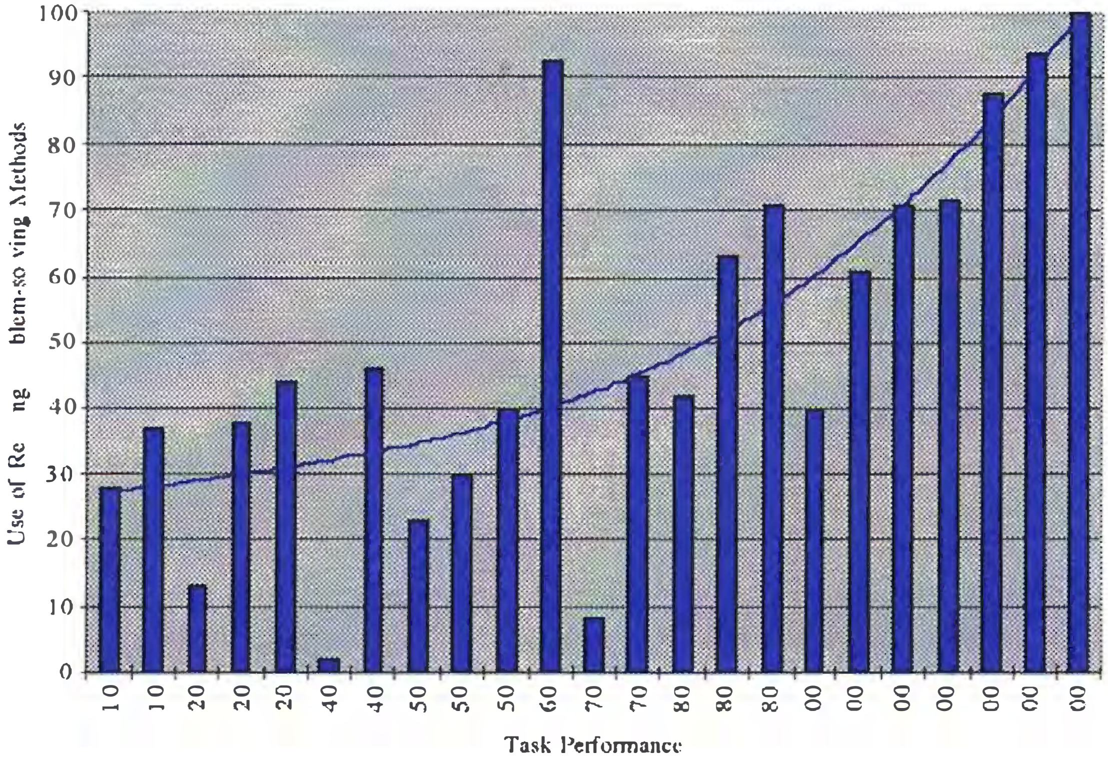


Figure 26. Correlation between Task Performance and Use of Reading Problem-solving Methods

The correlation between task performance and percent of problem-solving time spent using non-reading methods is shown in Figure 27. There was a correlation of negative one between task performance and use of non-reading problem-solving methods. Task performance decreased as use of non-reading problem-solving methods increased. The relationship was outside the scope of this research. However, in future research it might be beneficial to explore the relationship between task performance and method of problem-solving using a different experimental design.

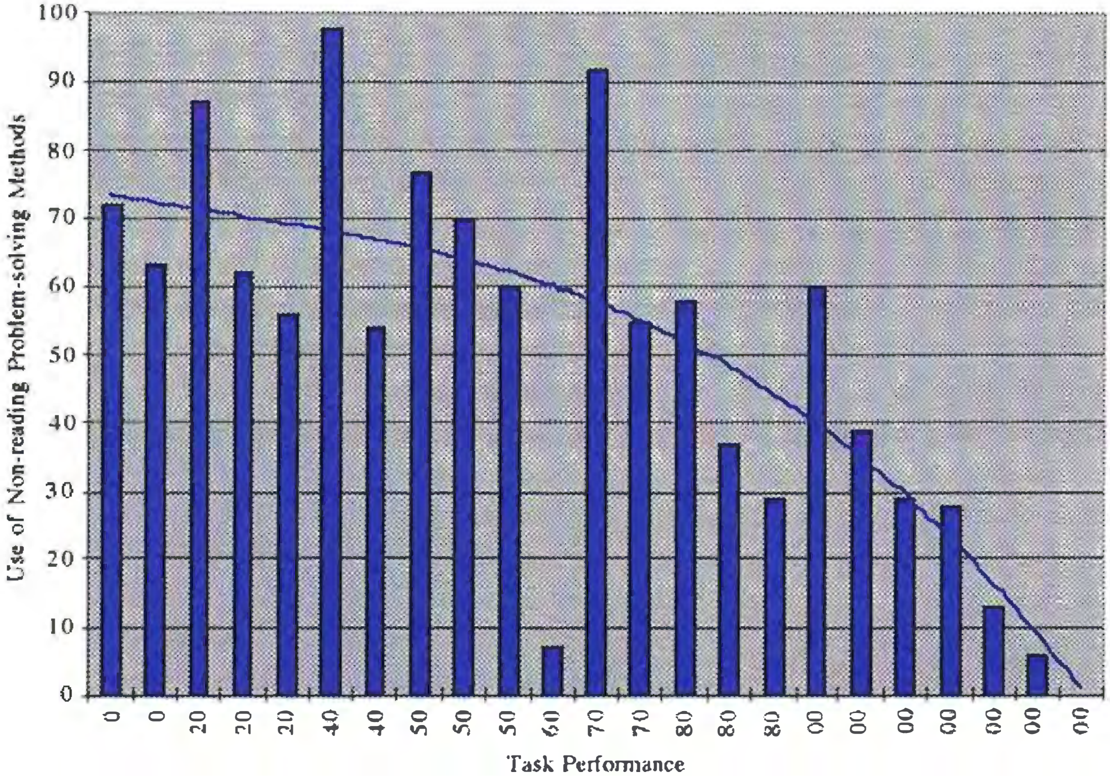


Figure 27. Correlation between Task Performance and Use of Non-reading Problem-solving Methods

REFERENCES

The American Heritage College Dictionary. New York: Houghton Mifflin Company, 1993. 673+713.

Allwood, C.M. "Novices on the Computer: A Review of the Literature." International Journal of Man-Machine Studies Vol. 25 (1986): 633-658.

Bennett, John, and Gene Lynch. ACM Conference on Human Factors in Computing Systems : Striking a Balance. CHI '92. Eds. Penny Bauersfeld, John Bennett and Gene Lynch. Monterey, California: Addison-Wesley Pub, 1992. 713.

Bishop-Clark, Catherine, and Daniel D. Wheeler. "The Myers-Briggs Personality Type and Its Relationship to Computer Programming." Journal of Research on Computing in Education Vol. 26.3 (1994, Spring): 358-370.

Campbell, D.E., and C.L. Davis. "Improving Learning by Combining Critical Thinking Skills with Psychological Type." Air Force Institute of Technology, 1988.

Carland, J.A., and J.W. Carland. "Cognitive Styles and the Education of Computer Information Systems Students." Journal of Research on Computing in Education Vol. 23 (1990): 114-126.

Carlson, J. "Affirmative: In Support of Researching the Myers-Briggs Type Indicator." Journal of Counseling and Development Vol. 67 (1989): 484-486.

Carlson, R., and N. Levy. "Studies of Jungian Typography: Memory, Social Perception, and Social Action." Journal of Personality Assessment 41 (1973): 559-576.

Carlyn, M. "An Assessment of the Myers-Briggs Type Indicator." Journal of Personality Assessment Vol. 41 (1977): 461-473.

Carroll, John M., ed. Designing Interaction : Psychology and the Human-Computer Interface. New York: Cambridge University Press, 1991. 333.

Cheng, T.T., B Plake, and D.J. Stevens. "A Validation Study of the Computer Literacy Examination: Cognitive Aspects." AEDS Journal Vol. 18. No. 3 (1985): 139-151.

Coan, R.W, ed. Critique of the Mvers-Briggs Tvpe Indicator. In O.K. Buros The Eighth Mental Measurement Yearbook. Highland Park: Gryphon, 1978. 973-975.

Corman, L. "Cognitive Style, Personality Type, and Learning Ability as Factors in Predicting the Success of the Beginning Programming Students." SIGCSE Bulletin Vol. 18. No. 4 (1986): 80-89.

Cronbach, L.J. Essentials of Psychological Testing. 5th ed. NY: Harper and Row, 1990.

Damos, Diane L, ed. Multiple-Task Performance. Hayden ed. Washington DC: Taylor & Francis, 1991. 469.

Devito, A.J., ed. Review of the Mvers-Briggs Tvpe Indicator. In J. Mitchell (Ed.). The Ninth Mental Measurement Yearbook. Highland Park: Gryphon, 1985. 1030-1032.

Diaper, Dan, ed. Task Analysis for Human-Computer Interaction. New York, NY: 1989. 258.

Downton, Andy, ed. Engineering the Human-Computer Interface. New York McGraw-Hill Book Co.,: McGraw-Hill Book Co., 1991. 423.

Dumas, Joseph S., and Janice C. Redish. "A Practical Guide to Usability Testing." Norwood, NJ: Ablex Pub. Corp., 1993. 412.

Dyck, Jennifer L., and Vana Al-awar Smither. "Age Differences in Computer Anxiety: The Role of Computer Experience, Gender and Education." Journal of Educational Computing Research Vol. 10.3 (1994): 239-248.

Ericsson, A.K., and H.A. Simon. Protocol Analvsis: Verbal Reports as Data. Cambridge, MA: MITPress, 1993.

Evans, G., and M. Simkin. "What Best Predicts Computer Proficiency." Communications of the ACM Vol. 32 (1989): 1322-1327.

Famighetti, Robert, ed. The World Almanac and Book of Facts 1995. Mahwah, NJ: Funk & Wagnalls Corp., 1994. 975.

Fetler, M. "Sex Differences on the California Statewide Assessment of Computer Literacy." Sex Roles Vol. 13. No. 3/4 (1985): 181-191.

Frisbie, G. R. "Cognitive Styles: An Alternative to Keirsey's Temperaments." Journal of Psychological Type Vol. 16 (1988): 13-21.

Gabriel, R. M. "Assessing Computer Literacy: A Validated Instrument and Empirical Results." AEDS Journal Vol. 18. No. 3 (1985a): 153-171.

Gabriel, R. M. "Computer Literacy Assessment and Validation: Empirical Relationships at Both Student and School Levels." Journal of Educational Computing Research Vol. 1. No. 4 (1985b): 415-425.

Garden, A. "Unresolved Issues with the Myers-Briggs Type Indicator." Journal of Psychological Type Vol. 22 (1991): 3-14.

Gilroy, F. D. "Computer Anxiety: Sex, Race and Age." International Journal of Man-Machine Studies Vol. 25 (1986): 711-719.

Globerson, T., and T. Zelniker, eds. Cognitive Style and Cognitive Development. Norwood, NJ: Ablex Publishing, 1989.

Hakkinen, Paivi. "Changes in Computer Anxiety in a Required Computer Course." Journal of Research on Computing in Education Vol. 27.2 (1994-95, Winter):

Hancock, Peter a, ed. Human Factors Psychology. New York, NY: Elsevier Science Pub Co, 1987. 433.

Heinssen, R. K., C.R. Glass, and L.A. Knight. "Assessing Computer Anxiety: Development and Validation of the Computer Anxiety Rating Scale." Computers in Human Behavior 3 (1987): 49-59.

Hicks, Richard, and James Essinger. Making Computers More Human : Designing for Human-Computer Interaction. Oxford Elsevier Advanced Technology: Elsevier Advanced Technology, 1991. 157.

Hoffman, J. I., K. Waters, and M. Berry. "Personality Types and Computer Assisted Instruction in a Self-Paced Technical Training Environment." Research in Psychological Type 3 (1981): 81-85.

Igbaria, M., and S. Parasuraman. "A Path Analytic Study of Individual Characteristics, Computer Anxiety, and Attitudes Toward Microcomputers." Journal of Management 15 (1989): 373-388.

ISACS. "Mission: Define Computer Literacy." The Computing Teacher (1985, November): 10-15.

Jackson, W.J., D. G. Clements, and L.G. Jones. "Computer Awareness and Use at a Research University." Journal of Educational Technology Systems Vol. 13. No. 1 (1984-1985): 47-56.

Johnson, D. C., et al. "Computer Literacy- What is it?" Mathematics Teacher (1980, Feb.): 91-96.

Johnson-Laird, P.N. Mental Models: Toward a Cognitive Science of Language, Inference, and Consciousness. Cambridge, MA: Harvard University Press, 1983.

Jones, W. Paul. "Computer Use and Cognitive Style." Journal of Research on Computing in Education Vol.26 No. 4 (1994, Summer): 514-522.

Jung, Carl G. Psychological Types. Trans. H. G. Baynes. Princeton, NJ: Princeton University Press, 1971.

Kato, T. "What 'Question-Asking Protocols' Can Say About the User Interface." International Journal of Man-Machine Studies Vol. 25 (1986): 659-673.

Kay, R.H. "Bringing Computer Literacy into Perspective." Journal of Research on Computing in Education Vol. 22. No. 1 (1989): 35-47.

Kay, R. H. "The Computer Literacy Potpourri: A Review of the Literature." Journal of Research on Computing in Education Vol. 24. No. 4 (1992b): 446-456.

Kay, Robin H. "A Practical Research Tool for Assessing Ability to Use Computers: The Computer Ability Survey (CAS)." Journal of Research on Computing in Education Vol. 26. No. 1 (1993 Fall): 16-27.

Kay, Robin H. "Understanding and Evaluating Measures of Computer Ability: Making a Case for an Alternative Metric." Journal of Research on Computing in Education Vol. 2. No 2 (1993 Winter): 270-281.

Keen, P.G.W., and G.S. Bronsema. "Cognitive Style Research: A Perspective for Integration." Proceedings of the Second International Conference on Information Systems. 1981. 21-52.

Keirsey, D., and M. Bates. Please Understand Me. Del Mar CA: Prometheus Nemesis Books, 1984.

Keyser, Daniel J., and Richard C. Sweetland, eds. Myers-Briggs Indicator. Test Critiques Compendium. Kansas City, MO: Test Corporation of America, 1987. 327-336.

Keyser, Daniel J., and Richard C. Sweetland, eds. Computer Anxiety Index (Version AZ) Revised. 10 vols. Test Critiques. Austin, TX: Pro-Ed, Inc., 1994. 164-171.

Kirwan, B., and L. K. Ainsworth, eds. A Guide to Task Analysis. Washington DC: Taylor & Francis, 1992. 417.

Kramer, Jack J., and Jane Close Conoley, eds. The 10th Mental Measurements Yearbook. Lincoln, NB: The Buros Institute of Mental Measurements, 1984. 765.

Larson, J., and C. Unger. "Engineering for Human-Computer Interaction." IFIP Working Conference on Engineering for Human-Computer Interaction. Eds. J. Larson and C. Unger. Ellivuori, Finland: New York : North-Holland, 1992. 423.

Laurel, Brenda, ed. The Art of Human-Computer Interface Design. Reading, MA: Addison-Wesley Pub. Co, 1990. 523.

Lawrence, G. "A Synthesis of Learning Style Research Involving the MBTI." Journal of Psychological Type Vol. 8 (1984): 2-15.

Levin, D. "Everyone Wants 'Computer Literacy' So Maybe We Should Know What it Means." The American School Board Journal (1983): 25-28.

Liu, Min, W. Michael Reed, and Perry D. Phillips. "Teacher Education Students and Computers: Gender, Major, Prior Computer Experience, Occurrence, and Anxiety." Journal of Research on Computing in Education Vol.24. No. 4 (1992, Summer): 457-467.

Lockheed, M.E., A. Nielsen, and M.K. Stone. "Determinants of Microcomputer Literacy in High School Students." Journal of Educational Computing Research Vol. 1. No. 1 (1985): 81-96.

Loyd, B. H., and C. Gressard. "Reliability and Factorial Validity of Computer Attitude Scales." Educational and Psychological Measurement Vol. 44 (1984): 501-505.

Maybury, Mark T., ed. Intelligent Multimedia Interfaces. Menlo Park, Calif. AAAI Press: AAAI Press, 1993. 405.

McCaulley, M. H. Jung's Theory of Psychological Type and the Myers-Briggs Type Indicator. Gainesville, FL: Center for Applications of Psychological Type, Inc., 1981.

McCaulley, M.H. "The Myers-Briggs Type Indicator: A Jungian Model for Problem-solving." New Directions for Teaching and Learning Vol. 30 (1987): 37-53.

McCrae, R.R., and P.T. Costa Jr. "Reinterpreting the Myers-Briggs Type Indicator from the Perspective of the Five-Factor Model of Personality." Journal of Personality Vol. 57 (1989): 17-40.

Mendelsohn, G.E., ed. Critique of the Myers-Briggs Type Indicator. In O.K. Buros (Ed.), The First Mental Measurement Yearbook. Highland Park: Gryphon, 1965. 321-322.

Monk, Andrew. "Improving Your Human-Computer Interface : A Practical Technique." New York Prentice Hall: Prentice Hall, 1993. 99.

Myers, I.B., and M.H. McCaulley. Manual: A Guide to Development and Use of the Myers-Briggs Type Indicator. Palo Alto, CA: Consulting Psychologists Press, 1985.

Myers, I.B., and P.B. Myers. Gifts Differing. Palo Alto, CA: Consulting Psychologists Press, 1980.

Norman, Kent L. The Psychology of Menu Selection : Designing Cognitive Control at the Human-Computer Interface. Norwood, NJ Ablex Pub. Corp.: Ablex Pub. Corp., 1991. 350.

Overbaugh, Richard C., and W. Michael Reed. "Effects of an Introductory Versus a Content-Specific Computer Course on Computer Anxiety and Stages of Concern." Journal of Research on Computing in Education Vol.27. No. 2 (1994-1995 Winter): 211-220.

Page, Colleen, and Mansour Rahimi. "Concurrent and Retrospective Verbal Protocols in Usability Testing: Is There Value Added in Collecting Both?" Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting. 2 vols. San Diego, CA: Human Factors and Ergonomics Society, 1995. 1: 223-227.

Parry, H.J., and H.M. Crossley. "Validity of Responses to Survey Questions." Public Opinion Quarterly Vol. 14 (1950): 61-80.

Preece, Jenny, ed. A Guide to Usability : Human Factors in Computing. Reading, Mass. Addison-Wesley: Addison-Wesley, 1993. 144.

Reed, W. M., and D. B. Palumbo. "The Effect of the BASIC Programming Language on Problem-solving Skills and Computer Anxiety." Computers in the Schools 4.3/4 (1987/1988): 91-104.

Reed, W. M., and D. B. Palumbo. "The Effect of the BASIC Programming Language on Problem-solving Skills Over an Extended Period of Time." Journal of Educational Computing Research 8.3 (1992): 357-371.

Rhodes, L. A. "On Computers, Personal Styles, and Being Human: A Conversation with Sherry Turkle." Educational Leadership Vol. 43. No. 6 (1986): 12-16.

Rosen, L. D., D. C. Sears, and M. M. Weil. Computerphobia Measurement- A Manual for Administration and Scoring of Three Instruments: Computer Anxiety Rating Scale, Attitudes Towards Computers Scale, Computer Thoughts Survey. Dominguez Hills, CA: California State University, 1987.

Sacks, Colin H., Yolanda Bellisimo, and John Mergendoller. "Attitudes Toward Computers and Computer Use: The Issue of Gender." Journal of Research on Computing in Education Vol. 26. No. 2 (1993 Winter): 256-269.

Schneiderman, D. Software Psychology: Human factors in Computer and Information Systems. Cambridge, MA: Winthrop Publishers, 1980.

Seymour, Philip H. K. Human Visual Cognition: A Study in Experimental Cognitive Psychology. New York: St. Martin's Press, 1979. 350.

Shih, Yu-Fen, and Stephen M. Alessi. "Mental Models and Transfer of Learning in Computer Programming." Journal of Research on Computing in Education Vol. 26. No 2 (1993 Winter): 154-175.

Simonson, Michael R., et al. Test Administrator's Manual for the Standardized Test of Computer Literac and Computer Anxiety Index. Ames, Iowa: Iowa State Research Foundation, Inc., 1992. 247.

Slinger, Allen, ed. Human-machine Interactive Systems. New York Plenum Press: Plenum Press, 1991. 328.

Smith, D. D. "A Study of Learner Characteristics and Computer Assisted Instruction Decision Making." Doctoral Dissertation. Ohio State University Microfilms No. 72-15, 297, 1972.

Specular International. Infini-D Tutorial Manual. Amherst MA: Specular International, 1992. 84.

Spielberger, C. D., H. J. O'Neill, and H. H. Duncan. "Anxiety, Drive Theory, and Computer Assisted Learning." Progress in Experimental Personality Research 6 (1972): 109-148.

Sullivan, Joseph W., and Sherman W. Tyler, eds. Intelligent User Interfaces. New York ACM Press: ACM Press, 1991. 472.

Waern, Yvonne. Cognitive Aspects of Computer Supported Tasks. Chichester, England: 1989. 307-320.

Wesley, B.E., G. H. Krockover, and C.R. Hicks. "Locus of Control and Acquisition of Computer Literacy." Journal of Computer-Based Instruction Vol. 12. No. 1 (1985): 12-16.

Westbrook, P. "Frequencies of MBTI Types among Computer Technicians." Journal of Psychological Type Vol. 15 (1988): 49.

Wiggins, J.S., ed. Critique of the Myer-Briggs Indicator. J.C Conoley & J.J Kramer, The Tenth Mental Measurement Yearbook. Highland Park, NJ: Gryphon, 1989. 537-538.

Zelniker, T. "Cognitive Style and Dimensions of Information Processing." Cognitive Style and Cognitive Development. Norwood, NJ: Ablex Publishing, 1989. 172-191.

Zemke, R. "Second Thoughts About the MBTI." Training Vol. 29. No. 4 (1992): 43-47.

APPENDIX A

Revised Tutorial

INFINI-D™

TUTORIAL MANUAL

Figure 28. Cover of the Revised Tutorial

The 3D World

Infini-D creates a synthetic 3D World that includes (moving clockwise around the screen) Top, Camera, Right, and Front Views. These four Views will appear automatically each time you open Infini-D. In addition, Infini-D includes a function to access many other camera Views.

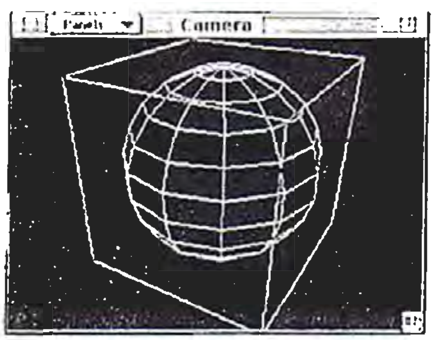
Relative Versus Absolute Movement

It is important to understand, before you begin, the concept of relative versus absolute movement.

After you select an object and place it in the 3D World, you can select the Horizontal or Vertical Plane Tools, and move the object along the X, Y, and Z axes. You will notice, as you move an object in one View, that it moves differently in the other Views.

This is because objects move relative to each View, NOT absolutely. Imagine watching a train pass by. To a person waiting in their car, the train would be moving left to right (or right to left.) But to a person behind the train, it would appear to be getting smaller as it moved away. Infini-D allows you to move the object relative to the View you are in. This concept will become more clear as you proceed through this lesson and the rest of the Tutorial.

Selecting An Object in the 3D World



A six-sided bounding box will blink around selected objects.

To select an object in the 3D World, move the mouse pointer to the object you want to select and click once. A blinking box will surround the object to indicate that it is selected.

If you want to use a tool, select the tool first, then select the object on which you want to use the tool.

If you want to use a menu item, select the object, then select the menu and menu item you want. It is important that you select the object before you select a menu item.

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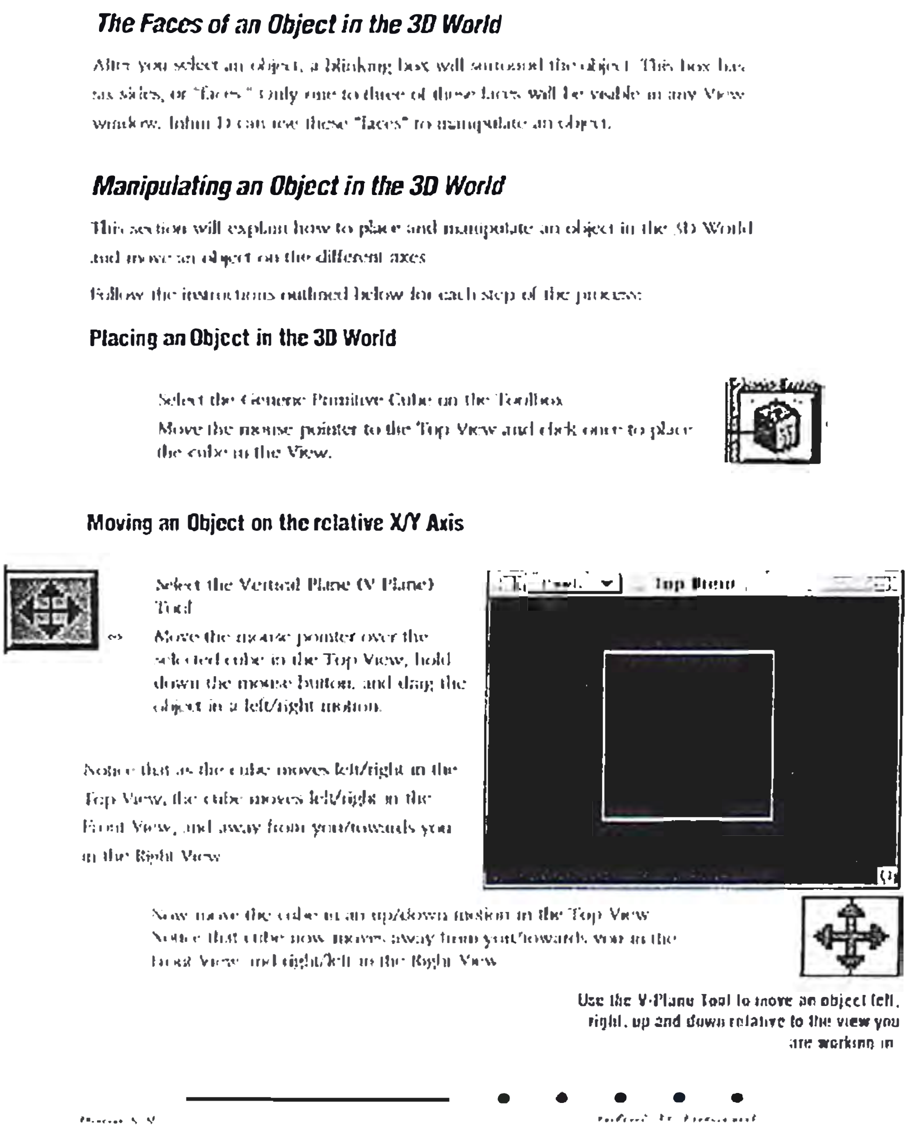
Lesson 1: Building a Simple Model

Figure 29. First Page of the Revised Tutorial



The Faces of an Object in the 3D World

After you select an object, a blinking box will surround the object. This box has six sides, or "faces." Only one to three of these faces will be visible in any View window. Infini-D can use these "faces" to manipulate an object.

Manipulating an Object in the 3D World

This section will explain how to place and manipulate an object in the 3D World and move an object on the different axes

Follow the instructions outlined below for each step of the process:

Placing an Object in the 3D World

Select the Generic Primitive Cube on the Toolbox

Move the mouse pointer to the Top View and click once to place the cube in the View.

Moving an Object on the relative X/Y Axis

Select the Vertical Plane (V Plane) Tool

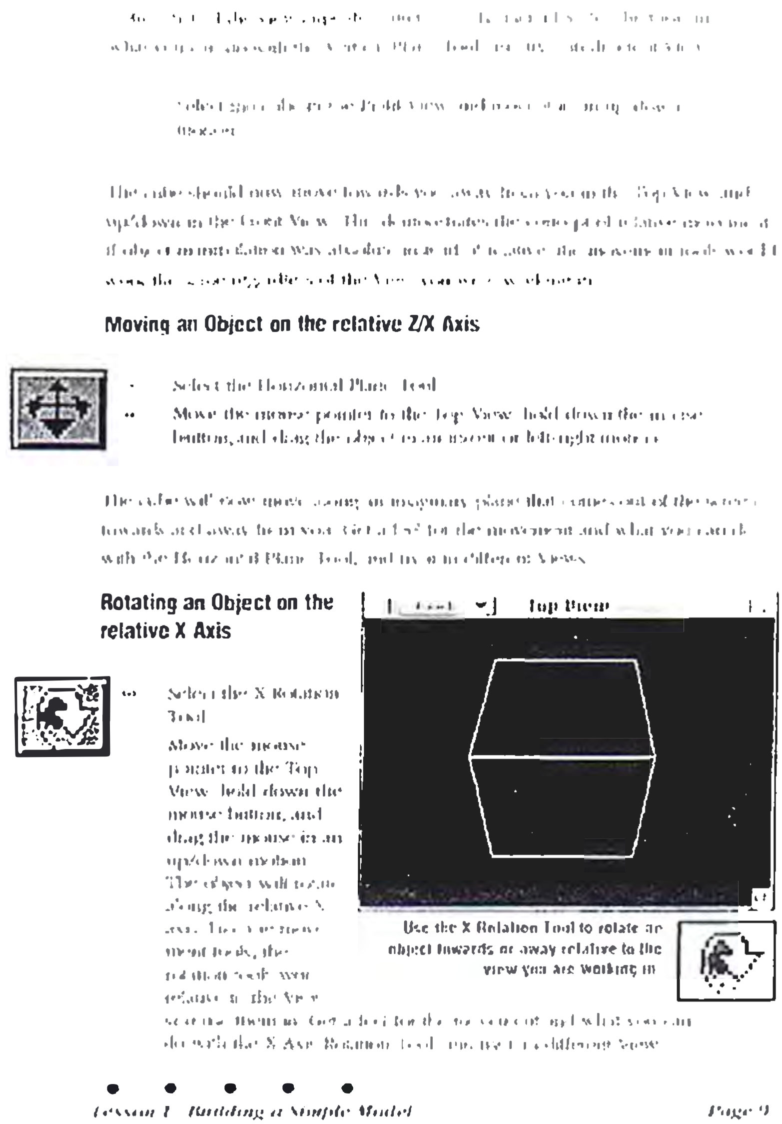
Move the mouse pointer over the selected cube in the Top View, hold down the mouse button, and drag the object in a left/right motion.

Notice that as the cube moves left/right in the Top View, the cube moves left/right in the Front View, and away from you/towards you in the Right View

Now move the cube in an up/down motion in the Top View. Notice that cube now moves away from you/towards you in the Front View and right/left in the Right View

Use the V-Plane Tool to move an object left, right, up and down relative to the view you are working in

Figure 30. Second Page of the Revised Tutorial



Moving an Object on the relative Z/X Axis

Rotating an Object on the relative X Axis

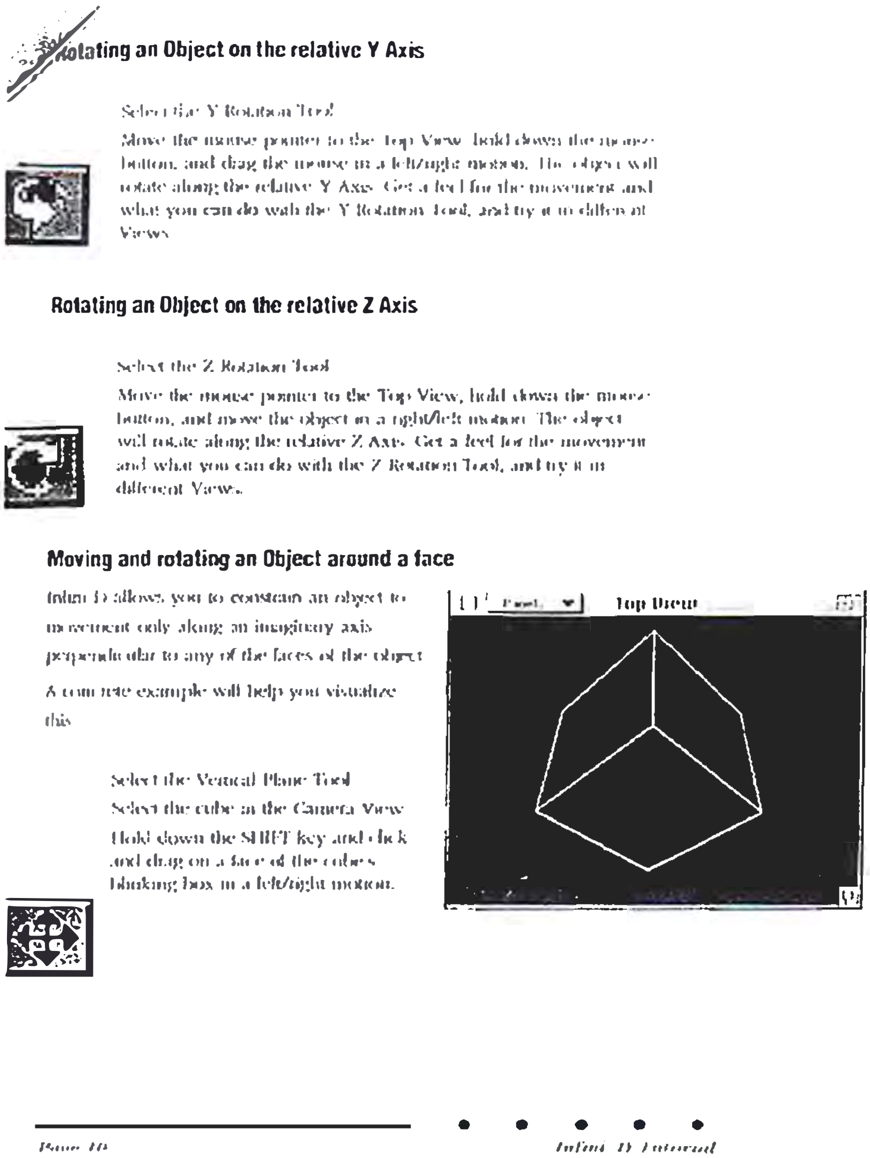
Top View

Use the X Rotation Tool to rotate an object towards or away relative to the view you are working in

Lesson 1 Building a Simple Model

Page 9

Figure 31. Third Page of the Revised Tutorial



Rotating an Object on the relative Y Axis

Select the Y Rotation Tool

Move the mouse pointer to the Top View, hold down the mouse button, and drag the mouse in a left/right motion. The object will rotate along the relative Y Axis. Get a feel for the movement and what you can do with the Y Rotation Tool, and try it in different Views.

Rotating an Object on the relative Z Axis

Select the Z Rotation Tool

Move the mouse pointer to the Top View, hold down the mouse button, and move the object in a right/left motion. The object will rotate along the relative Z Axis. Get a feel for the movement and what you can do with the Z Rotation Tool, and try it in different Views.

Moving and rotating an Object around a face

Infini-D allows you to constrain an object to movement only along an imaginary axis perpendicular to any of the faces of the object.

A concrete example will help you visualize this.

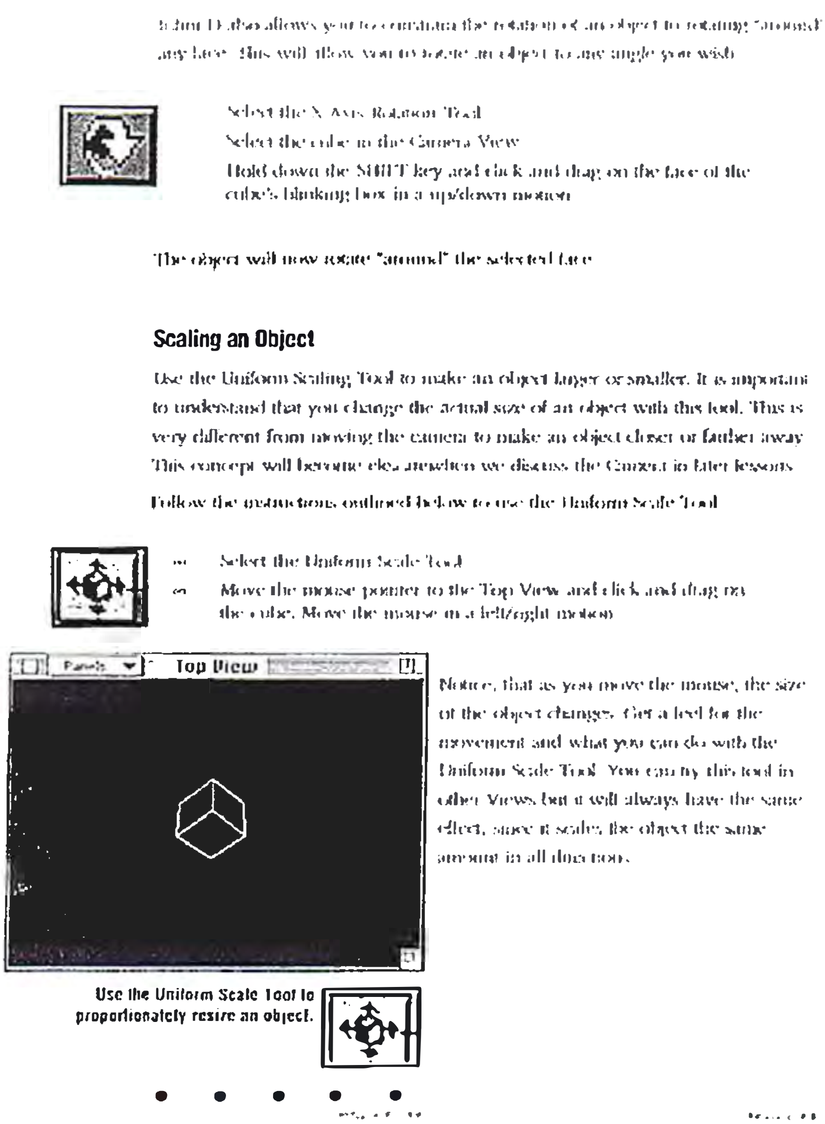
Select the Vertical Plane Tool

Select the cube in the Camera View

Hold down the SHIFT key and click and drag on a face of the cube's bounding box in a left/right motion.

Infini-D Tutorial

Figure 32. Fourth Page of the Revised Tutorial



Infini-D also allows you to constrain the rotation of an object to rotating "around" any face. This will allow you to rotate an object to any angle you wish.

Select the X Axis Rotation Tool

Select the cube in the Camera View

Hold down the SHIFT key and click and drag on the face of the cube's bounding box in a up/down motion

The object will now rotate "around" the selected face

Scaling an Object

Use the Uniform Scaling Tool to make an object larger or smaller. It is important to understand that you change the actual size of an object with this tool. This is very different from moving the camera to make an object closer or farther away. This concept will become clear when we discuss the Camera in later lessons.

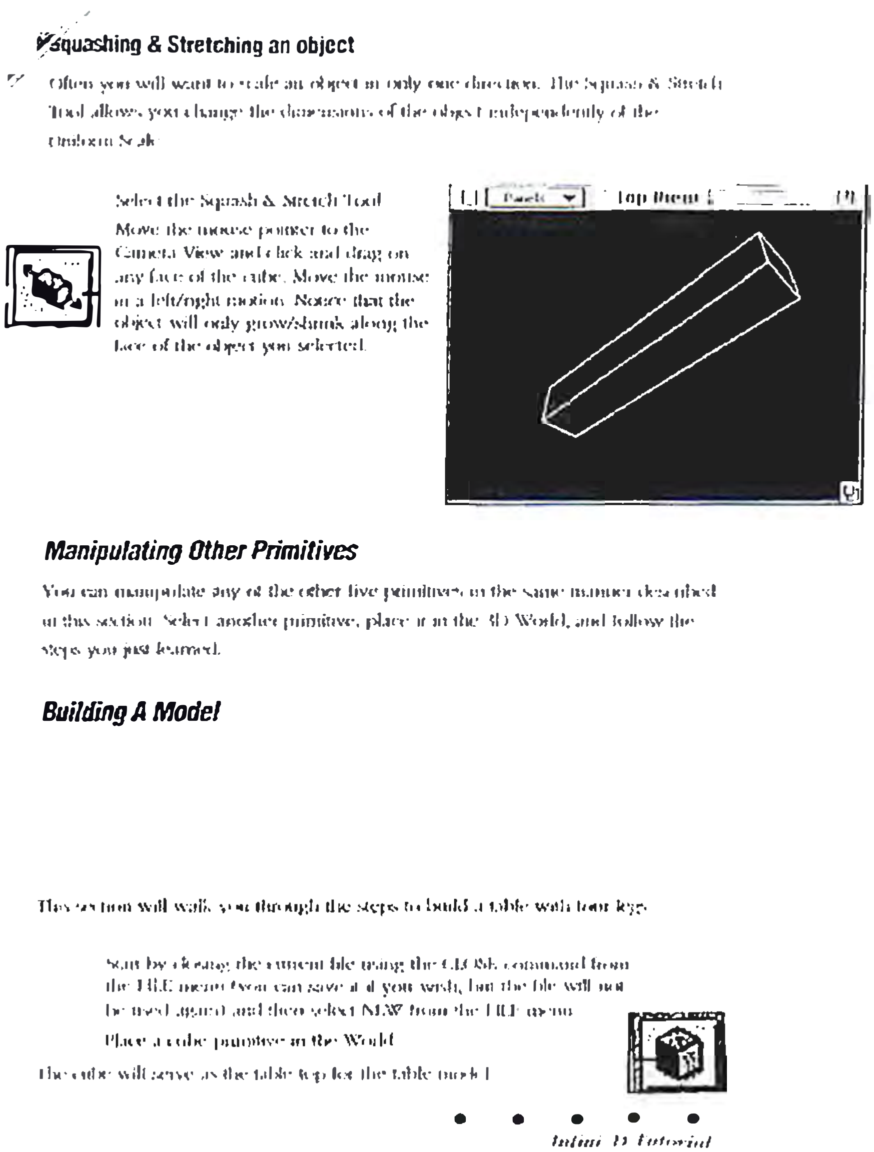
Follow the instructions outlined below to use the Uniform Scale Tool

- Select the Uniform Scale Tool
- Move the mouse pointer to the Top View and click and drag on the cube. Move the mouse in a left/right motion

Notice, that as you move the mouse, the size of the object changes. Get a feel for the movement and what you can do with the Uniform Scale Tool. You can try this tool in other Views but it will always have the same effect, since it scales the object the same amount in all directions.

Use the Uniform Scale Tool to proportionately resize an object.

Figure 33. Fifth Page of the Revised Tutorial



Squashing & Stretching an object

Often you will want to scale an object in only one direction. The Squash & Stretch Tool allows you change the dimensions of the object independently of the Uniform Scale.

Select the Squash & Stretch Tool

Move the mouse pointer to the Camera View and click and drag on any face of the cube. Move the mouse in a left/right motion. Notice that the object will only grow/shrink along the face of the object you selected.

Manipulating Other Primitives

You can manipulate any of the other five primitives in the same manner described in this section. Select another primitive, place it in the 3D World, and follow the steps you just learned.

Building A Model

This section will walk you through the steps to build a table with four legs.

Start by closing the current file using the CLOSE command from the FILE menu (you can save it if you wish, but the file will not be used again) and then select NEW from the FILE menu.

Place a cube primitive in the World

The cube will serve as the table top for the table model.

Infini D Tutorial

Figure 34. Sixth Page of the Revised Tutorial

Sizing the Table Top

In this section, you will learn how size the cube on the screen so it will look like a table top. Follow the instructions outlined below.

Select the cube.

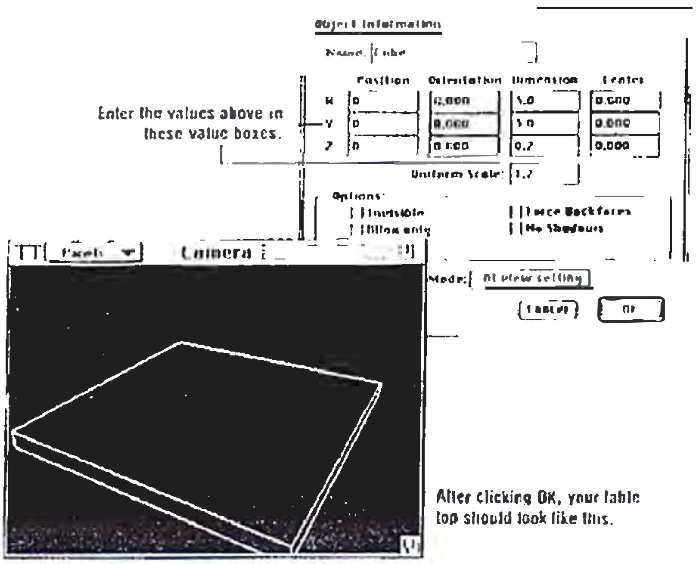
Select the OBJECT INFO command in the MODEL menu.

After you select OBJECT INFO, the Object Information dialog box will appear. This box allows you to adjust all parameters of the object.

Enter the following settings to create the table top:

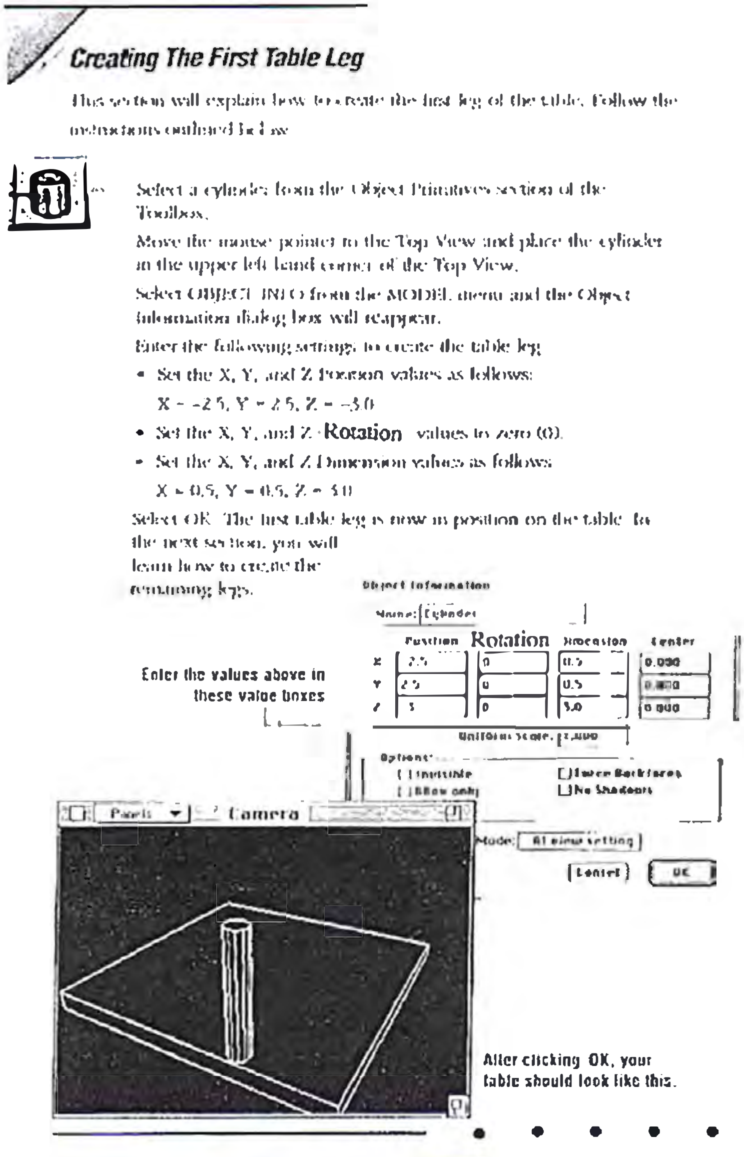
- Set the X, Y, and Z Position values to zero (0).
- Set the X, Y, and Z Rotation values to zero (0).
- Set the X, Y, and Z Dimension values as follows:
  X = 3.0, Y = 3.0, Z = 0.2
- Set the Uniform Scale value to 1.2.

Click OK. You have now have the correct dimensions for a table top.



Lesson 1: Building a Simple Model

Figure 35. Seventh Page of the Revised Tutorial



Creating The First Table Leg

This section will explain how to create the first leg of the table. Follow the instructions outlined below.

Select a cylinder from the Object Primitives section of the Toolbox.

Move the mouse pointer to the Top View and place the cylinder in the upper left hand corner of the Top View.

Select OBJECT INFO from the MODEL menu and the Object Information dialog box will reappear.

Enter the following settings to create the table leg:

- Set the X, Y, and Z Position values as follows:
  X = -2.5, Y = 2.5, Z = -3.0
- Set the X, Y, and Z Rotation values to zero (0).
- Set the X, Y, and Z Dimension values as follows:
  X = 0.5, Y = 0.5, Z = 3.0

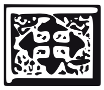
Select OK. The first table leg is now in position on the table. In the next section, you will learn how to create the remaining legs.

Figure 36. Eigth Page of the Revised Tutorial

Creating the Remaining Table Legs

This section will explain how to create and place the remaining three legs on the table.

Follow the instructions outlined below to create the remaining table legs.



- Select the Vertical Plane Tool from the Toolbox.
- Move the mouse pointer to the Front View and click on the table leg (the object will blink to show that it has been selected.)

Go to the MODEL menu and select DUPLICATE.

DUPLICATE allows you to create an exact copy of the selected object. In this case, you will make a duplicate of the table leg you just created.

After you select DUPLICATE, an identical table leg will appear next to the first table leg.

The second table leg should be blinking, indicating that it is selected. If not, move to the Front View and click on the second table leg.

Select OBJECT INFO from the MODEL menu and the Object Information dialog box will reappear.

Enter the following settings to place the second table leg:

- Leave Rotation and Dimension the same
- Set the X, Y, and Z Position values as follows:

  X = 2.5, Y = 2.5, Z = –3.0

- To create leg three, move to the Front View and (if it is not selected already) select leg two (click on it and it will blink.)

Go to the MODEL menu and select DUPLICATE.

An identical leg will appear next to leg two. Go to the MODEL menu again, then select OBJECT INFO and the Object Information dialog box will reappear.

Figure 37. Ninth Page of the Revised Tutorial

Enter the following settings to place the third table leg:

- Leave Orientation and Dimension the same
- Set the X, Y, and Z Position values as follows:

  X = [illegible], Y = [illegible], Z = [illegible]

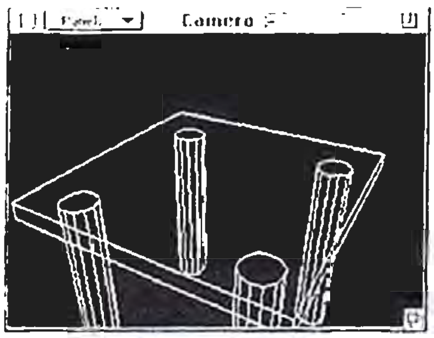
Repeat the steps outlined above to create the fourth table leg.

Enter the following settings to place the fourth table leg:

- Leave Orientation and Scaling the same
- Set the X, Y, and Z Position values as follows:

  [illegible], Z = [illegible]

You should now have a table with four legs that looks like the picture shown below.



Your finished table should look like this.

Locking The Model

When a carpenter builds a table, he or she creates the table top and the legs separately and then fastens them together with nails or glue. By fastening them together, he or she turns five parts into one usable object that won't fall apart as it is moved around. [illegible] gives you a similar ability with the Lock Tool. The Lock Tool allows you to lock the objects of the model together so that when you move one of the objects, all the locked elements move together. This helps you deal with individual objects in a complex model and simplifies the process of moving and rotating them within the 3D World.

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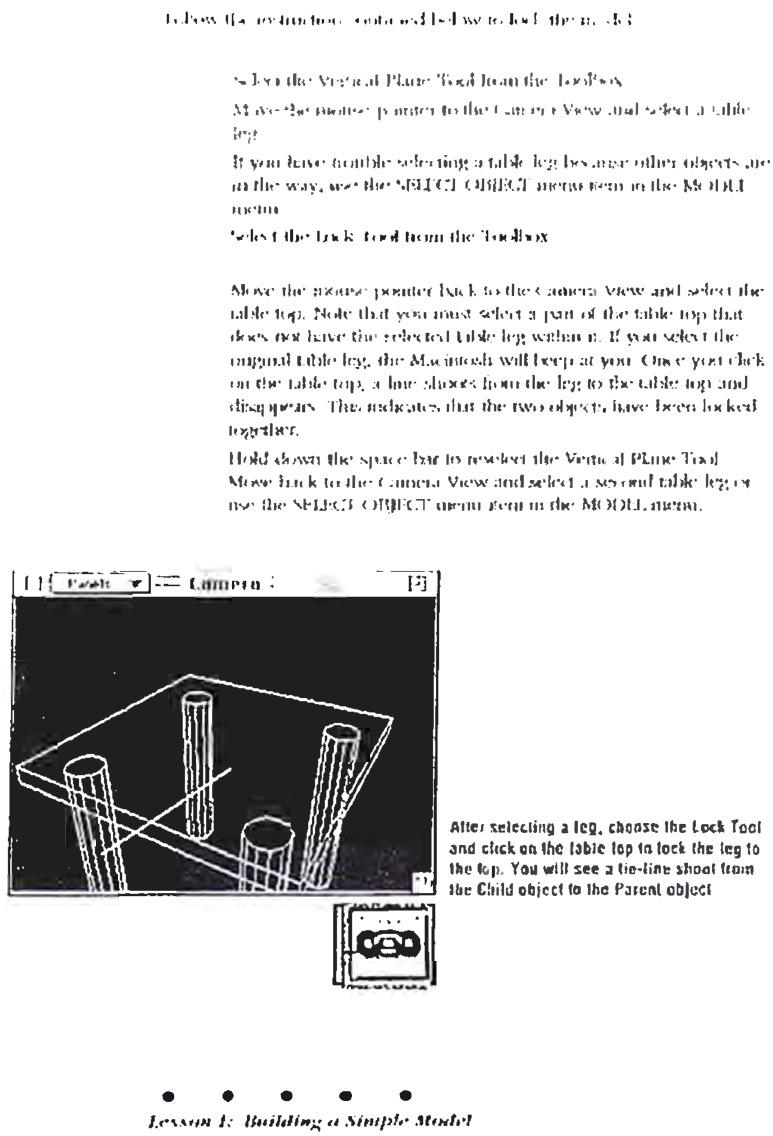
Figure 38. Tenth Page of the Revised Tutorial



Follow the [illegible]

Select the Vertical Plane Tool from the ToolBox.

Move the mouse pointer to the Camera View and select a table leg.

If you have trouble selecting a table leg because other objects are in the way, use the SELECT OBJECT menu item in the MODEL menu.

Select the Lock Tool from the ToolBox.

Move the mouse pointer back to the Camera View and select the table top. Note that you must select a part of the table top that does not have the selected table leg within it. If you select the original table leg, the Macintosh will beep at you. Once you click on the table top, a line shoots from the leg to the table top and disappears. This indicates that the two objects have been locked together.

Hold down the space bar to reselect the Vertical Plane Tool. Move back to the Camera View and select a second table leg or use the SELECT OBJECT menu item in the MODEL menu.

After selecting a leg, choose the Lock Tool and click on the table top to lock the leg to the top. You will see a tie-line shoot from the Child object to the Parent object

Figure 39. Eleventh Page of the Revised Tutorial

You can hold down the space bar anytime to use the Vertical Plane tool. Releasing the space bar will restore you to the previously selected tool.

Release the space bar and the Lock tool will be reselected. Select the table top again to link the second leg and the table top.

Repeat the step above until all the table legs are linked with the table top.

To test the lock, select the Vertical Plane Tool. Move the mouse pointer to the Top View, click on the table top and drag the mouse in an up/down motion. If whole table is locked together, it will move as one *object*. If the object is not completely locked, one or more parts will be left behind when you attempt to move the table.

If this is the case, go back to the beginning of this section and try again.

NOTE

If you try to drag one of the table legs it will separate from the rest of the table. This does not mean that the lock was not successful. Just as a carpenter has many ways of joining parts together (nails, screws, and glue,) Infini-D provides you with many different types of locks. A more detailed explanation of what these locks are and why you can move the table legs separately but not the table top will appear in the User's Manual.

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Figure 40. Twelfth Page of the Revised Tutorial

Saving The Model

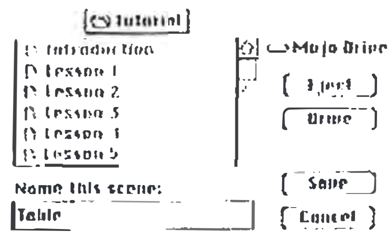
After you create a model, you will want to save it. Follow the instructions outlined below to save the model you created in this lesson.

Select the FILE menu

⇨ Select SAVE and the Save Dialog will appear

Enter a name for the file such as Table or Table1 or any name that has significance to you

Select SAVE when you are ready and the file will be saved



Use the Save Dialog to save your scene file to disk.

Congratulations! You have successfully completed Part One of Lesson One

Lesson 1: Building a Simple Model

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Figure 41. Thirteenth Page of the Revised Tutorial

APPENDIX B

Pilot Group Materials

INFORMATION LETTER

Dear Participant:

I am a graduate student under the direction of Professor Michael Kroelinger in the College of Architecture and Environmental Design at Arizona State University. I am conducting a pilot study entitled Human/Computer Interaction. The purpose of the research is to study human/computer interaction. Your will not be expected to perform any tasks that go beyond what is expected of a typical computer user (Using a mouse to interact with the screen).

Your participation will involve completing the Myers-Briggs Type Indicator. (the Myers-Briggs Type Indicator will be recorded only by your participant number). Then you will be asked to complete a survey recorded only by your participant number. Finally, you will be asked to complete exercises on the computer. The entire process is expected to take 2 hours. The participant numbers are only used to link the Myers-Briggs Type Indicator, survey and computer exercises.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, it will not affect your grade or compensation. The results of the research study may be published, but your name will not be recorded or used. You will be known only by your participant number. Also a video camera will be set up to record the computer screen. You will not be videotaped, only your interaction with the computer screen and your voice. There are not right or wrong answers or time limit, we are only concerned with your interaction with the exercises.

If you have any questions concerning the research study, please leave a message for Wendelin Geberth in the Design office: (602) 965-4135.

Sincerely,

Wendelin Geberth

PROCEDURE FOR PILOT GROUP

1. Bring the participant into the testing room.

2. Ask the participant to take a seat.

3. Hand the participant a copy of the Information Sheet and read it aloud.

Information Letter

Dear Participant:

I am a graduate student under the direction of Professor Michael Kroelinger in the College of Architecture and Environmental Design at Arizona State University. I am conducting a pilot study entitled Human/Computer Interaction. The purpose of the research is to study human/computer interaction. You will not be expected to perform any tasks that go beyond what is expected of a typical computer user (Using a mouse to interact with the screen).

Your participation will involve completing a test. (the test will be recorded only by your participant number). Then you will be asked to complete a survey recorded only by your participant number. Finally, you will be asked to complete exercises on the computer. The entire process is expected to take 2 hours. The participant numbers are only used to link the test, survey and computer exercises.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, it will not affect your grade or compensation. The results of the research study may be published, but your name will not be recorded or used. You will be known only by your participant number. Also a video camera will be set up to record the computer screen. You will not be recorded, only your interaction with the computer screen and your voice. There are not right or wrong answers or time limit, we are only concerned with your interaction with the exercises.

If you have any questions concerning the research study, please leave a message for Wendelin Geberth in the Design office: (602) 965-4135.

4. Ask for questions concerning the study.

5. Distribute the Computer Opinion Survey and a pencil, then read the instructions.

Instructions for Computer Opinion Survey

This is a two sided test. Please answer all of the questions on the first side of the test before continuing to the second side. Please mark all answers on the answer sheet. Please do not mark any of your answers on the question sheet. Use the pencil that you were given, make heavy black marks that fill the circle completely, erase cleanly any answer you wish to change, and make no stray marks on the answer sheet. This is simply a computer opinion survey, there are no right or wrong answers. Please do not think too long about any one answer.

Do you have any questions?

Please begin and tell me when you are finished.

6. When the participant is finished, collect the survey and place it in the folder of testing materials for that participant.
7. Distribute the Myers Briggs Type Indicator and a sharpened pencil, then read the instructions.

Instructions for the Myers-Briggs Type Indicator

There are no "right" or "wrong" an.wers to these questions. Your answers will help show how you like to look at things and how you like to go about deciding things.

Read each question carefully and indicate your answer by making an "X" in the appropriate box next to the response you select. Do not think too long about any question. If you cannot decide how to answer a question, skip it, and return later. If you make a mistake, do not erase (because there is carbon paper between the sheets of the test) instead, blacken in the box marked in error.

Please turn the booklet over and begin answering questions, there is no time limit, please tell me when you are finished.

8. When the participant is finished, collect the type indicator and place it in the folder of testing materials for that participant.
9. Direct the participant into the computer testing room and seat them at the computer.

10. TURN ON THE VIDEO CAMERA!!!!!

11. Explain the requirements for the verbal protocol analysis.

Verbal Protocol Analysis

Today you will be asked to complete part of a tutorial for the computer program Infini-D. It is a three-dimensional modeling program. You must read all instructions and directions aloud. Also, you must "think" aloud. Do not worry about differentiating between instructions and thoughts. Say whatever enters your mind while you are working on the tutorial, even if it is a thought like, "I am hungry, or this chair is uncomfortable." Do not worry about censoring what you say.

Please do not mark or alter the tutorial booklet in any way. I will remain in the room to remind you to verbalize any thoughts and actions. Please do not ask me any questions about the computer program because I cannot answer questions once the session has begun. There is no time limit. When you are done, please tell me.

Do you have any questions?

Please begin the tutorial and read and think aloud while working.

12. When the participant is finished, di tribute the final questionnaire and read the instructions.

Directions for the Questionnaire

Please fill out this questionnaire and tell me when you are finished.

13. When the participant is finished, collect the questionnaire and place it in the folder of testing materials for that participant.

14. Thank the participant and pay them.

QUESTIONNAIRE

Participant #________

What is your current major?____

What tasks do you use a computer for?

- ❐ never used a computer
- ❐ use a computer only for word processing
- ❐ use a computer only for drafting or 3-D modeling
- ❐ use a computer only for desktop publishing
- ❐ use a computer only for spread sheets and accounting

use a computer for multiple uses (check all that apply)

- ❐ word processing
- ❐ 3-D modeling
- ❐ desktop publishing
- ❐ spread sheets and accounting

List the names of the computer programs that you use at least once a month?

- ❐ none
- ❐ word processing: ____
- ❐ 3-D modeling: ____
- ❐ desktop publishing: ____
- ❐ spread sheets and accounting: _________________________________
- ❐ Other:____

How long have you been using a computer.

❐0-6 months ❐6 months-1 year ❐1 year ❐2 years ❐3 years ❐4 years ❐5+ years

How comfortable did you feel while completing this tutorial?

- ❐ very uncomfortable
- ❐ uncomfortable
- ❐ comfortable
- ❐ very comfortable

What do you feel is the difficulty level of this tutorial?

- ❐ very difficult
- ❐ difficult
- ❐ easy
- ❐ very easy