End-user documentation

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END-USER DOCUMENTATION

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ABSTRACT

The first and most basic problem with documentation is that the consumer of software applications does not want to use the documentation included with a software product for one or more reasons. Studies, and papers, have been done on the effect that documentation has on a user's satisfaction with a software application; its ease of use, how quickly a user can learn to use the application, and on how documentation should be standardized. The premise of this thesis is that an improvement to the software maintenance processes can be achieved by limiting maintenance requests to "actual" problems with software, versus "perceived" problems caused by inadequate end-user documentation.

After analyzing the literature within the computer science community on the software maintenance process, and the literature within the educational and psychological communities on learning, retention, and the effect of software documentation on the end-user, a modification to the Foster Model was conceived. This model incorporates the concept of an Interactive Documentation Program (IDP), which allows for the end-user to utilize end-user directed and task-based documentation to improve their skills with the operation of commercially available off-the-shelf "office application" software as well as in-house developed software of a similar nature.

To ascertain the viability of this concept, a world-wide survey of end-users concerning their needs, desires, expectations, and complaints concerning end-user documentation was conducted. Combining the statistical results of the analysis of this survey with the concept of the IDP resulted in a new visually-based and task oriented documentation paradigm called hypervideo.

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DEDICATION

This thesis is dedicated to my mother, Mildred, and my late father, Hugh, who always supported me in whatever endeavor, academic or career, which I undertook.

DECLARATION

All work contained within this thesis is the work of the author, and has not been previously submitted in this, or any other university, for a degree.

STATEMENT OF COPYRIGHT

Chapter 1

INTRODUCTION

1. Introduction

Software is a unique product. In theory, software should be the world's best product. Created in the minds of programmers, it is a product that could be, theoretically, created without defects. [LITTL92] Unfortunately, though, this is not the case. This product, like any other, must be maintained.

It has been stated that computer programming, and computers themselves for that matter, originated with the invention of the "Analytical Engine" by Charles Babbage during the time period of 1836 to 1849. This machine, entirely mechanical, was far ahead of the capabilities of the technology of the time period, and never became a functional reality during his lifetime. [AUGA84] Ada Augusta Byron, the Countess of Lovelace, detailed in remarkable depth the functionality and capabilities of the Analytical Engine, and even developed what we would call computer programs today. [RAND70]

Her scientific and mathematical works were appreciated by England's scientific leaders of the day, but it is doubtful that the Countess, as the first programmer [JAMES90], ever thought of ever maintaining her programs; the machine that they were intended to execute on did not exist. As time has passed by, though, other programmers have not been as fortunate, or unfortunate, as the Countess.

Towards the end of the Second World War, a team of research scientists was working on the development of the Mark I Automatic Sequence Controlled Calculator at Harvard University for the United States Navy and the IBM Corporation. [RITCH86] While the team was testing a program on the computer, mistakes in the expected output of the program began to appear. Suspecting a hardware problem, the team

searched for hours for a faulty electrical component, but instead found a moth wedged between two relays; hence breaking the circuit. [DIGN83] This moth, or "bug," not only stopped the Mark I development team from continuing with their project until the problem was corrected, but it simultaneously became the genesis of the field of software maintenance. Why? To this very day, programmers are ever in search of the "bug" that has caused their program to behave unexpectedly or inappropriately after they have spent hours upon hours of development time to ensure that their programs will work correctly.

Grace Hopper, a member of the development team of the Mark I [DIGN83] and who later became a United States Navy Admiral, was honored with her invention of the COBOL programming language. [ROHR94] The creation of COBOL turned a machine that was originally designed to be an implement of war into an integral part of the corporate world. COBOL allowed businesses to develop software quickly, and relatively easily. The only problem is that apparently no one ever thought of maintaining these programs, or of what the total cost or scope of what software maintenance would entail, or how widespread the use of software would become.

As the world grows smaller, either by individuals traveling around the world or by the Internet with its international reach, the need for a universal standard for user-level documentation and data display will only grow. How that standard is developed will determine the future of the world, for like the Middle Ages, we may be entering into another era of information haves and information have-nots, solely based on the ability to interact with a computer system application via its documentation and human interface.

2. The Thesis Position

2.1 Motivation for Thesis

The author has held many positions within the software development community during the course of his career. These positions have included the typical entry-level positions, as a programmer upon entry to the career, to senior-level managerial positions in computer operations and maintenance, and lastly, within collegiate

education within the United States. Over the course of this career, the author has managed many enterprise-wide projects, and has taught software development strategies and paradigms. One of these paradigms was the issue of software maintenance.

In choosing to return to school to complete this degree, the topic of a thesis and the area of research for this thesis forced the author to review his career and the various episodes within it. During the course of this examination, one common thread appeared: the end-user and the complications of dealing with the end-user during the course of the software development life cycle, especially during the maintenance phase of the life cycle. Regardless of the arena in which the author was employed, be it the defense industry, governmental, or educational entities, maintenance requests for problems with software were generated by the end-user, but inspection of these requests showed that the problem was not with the software product, but with the end-user's ability to utilize the product.

Further examination by the author through informal discussions with his employees and his customers showed that there were two distinct view-points on software documentation: the software development community considered the development of end-user documentation an after-thought, or a menial task to be delegated to entry-level people, and the end-user community considered documentation to be a major issue with their satisfaction of the software product.

Additionally, since the author has commenced a career in teaching computer science at the junior college level in the United States, he has noticed that there are no courses offered at his institution, nor none of the courses offered at any of the local major colleges and universities, that discuss the issues of end-user documentation nor how to properly prepare end-user documentation. This oversight, as well as the personal experiences of the author as a manager responsible for customer satisfaction on software products, led the author to conduct the enclosed research and to prepare this thesis.

2.2 Statement of the Problem

The first and most basic problem with documentation is that the consumer of software applications does not want to use the documentation for one or more, mostly psychological, reasons. The consumer wants results immediately. They have no interest, or desire, to search through volumes of written material on how to perform a simple task in an application on their computer, and consequently, will most likely consult another person, either a co-worker or a friend, on how to perform the desired task. [DENT93]

For those who do use the documentation that is provided with the application, either out of frustration or the inability to find someone who knows the hidden secret of performing the task, they quite frequently find that the documentation is either too complex to understand to adequately use the application, inaccurate or out-of-date, or is too voluminous to quickly find the solution. [CRIC83a, CROW92] This supports the conclusion of a 1986 study by Sullivan and Flower that those reading the documentation to do a task refer to the documentation selectively and infrequently. [CHAR91]

Assuming that the documentation is correct, up-to-date, complete, and not too voluminous, there still is the issue of documentation complexity versus the educational and reading level of the typical software application user, which in today's world, is virtually everyone.

2.2.1 Characterization of the Problem

This thesis is not attempting to solve the software industry's massive problems with software documentation, nor the problem with end-user documentation in general. For first of all, the computer industry has not developed a well-defined definition of what end-user documentation is, what it should contain, nor what specific purposeful functionality it should provide to the end-user. As such, and in particular, this thesis is directed toward providing a solution for those end-users that are supported by a "Help Desk," as defined within the limits and purpose of the Foster Model [FOST93], within an organization. As such, the scope of this thesis is to provide a remedy for the following two classes of end-user applications: software developed by an organization's

internal development team for use by individuals of the organization who work in a typical "office-like" environment, or, commercially-available off-the-shelf applications, such as word processing software packages, used by individuals of the organization which are supported by the organization's "Help Desk."

For example, a typical user of the proposed documentation paradigm offered in this thesis would be the typical office worker in a cubicle. As such, this user is not an expert at the operation of a software product, but a generalist; one who uses the computer only as a supporting role of their operational function within the organization, such as an accountant, a manager, or an educator. The applications which this individual will use are limited to non-real time or non-mission critical systems, such as word processing, electronic mail, spread sheets and so forth. Additionally, this user is supported by a "Help Desk" within the organization, which offers solutions to common problems associated with general software applications.

A typical example of the situation that this type of user finds himself in is infrequently performing a possibly complex task within a software application; such as creating an index for a document in Microsoft Word. Since the end-user performs this task infrequently, it is highly likely that they have either completely forgot how to perform the task or have forgotten a sufficient amount of material to make the task appear to work incorrectly. In either case, they will at some point approach the organization's "Help Desk" for assistance with the product, or to register a possible complaint about the product. In either case, the "Help Desk" is tasked with responding with a possible solution. In many "Help Desk" situations, such as the one here at Durham, or the ones that the author has managed, the solution is to provide the end-user with a "standardized" response, normally in the form of a "Help Sheet" designed to answer a broad spectrum of questions, not just the one at hand from the end-user in question.

Conversely, the individual to which this thesis is not directed is one who is expected to be an expert at the single function or task that they perform with a computer system in a mission critical or real-time environment. Such users would include, and are not limited to: a police dispatcher with a computer-aided dispatching software product, an

airline pilot with the on-board computer systems, or an anesthesiologist with the computers that monitor a patient during an operation.

From the above discussion, it is evident that the intended recipient of this research is the typical individual who has convenient access to a "Help Desk," and is a frequent user of such a resource, within either an academic, commercial, or industrial setting.

2.2.2 Thesis Structure

The interconnection between the chapters, as outlined above, is not linearly correlated, as the manner in which they are listed would imply. Figure 1-1 depicts the interconnection between the chapters and shows the influence on the resultant documentation paradigm.

As can be seen from Figure 1-1, the Literature Survey, conducted in Chapter 2, was essentially partitioned into two main categories: Software Maintenance and "Learning." From reviewing the literature that was available on Software Maintenance, the Foster Model was discovered as well as a noticeable lack of research by the computer science community in the area of end-user documentation.

Concurrently, from the survey of the literature in the fields of Education, Training, Educational Psychology, and Psychology, it was evident that there was an extensive amount of research conducted on the subject of "Learning." As a by-product of this research, the effects of software documentation on the end-user's ability to "learn," and retain knowledge of, how to use a software product.

From the combined analysis of the Foster Model and present state of end-user documentation, it was felt that a modification to the Foster Model could be developed to account for problems that are being handled by Help Desk personnel that are solely related to the quality, usability, and accuracy of the present documentation paradigm. This analysis resulted in the Modified Foster Model which has the notion of an Interactive Documentation Program (IDP) at its heart. In order for the IDP to effective, a new documentation paradigm needed to be developed.

To facilitate the development of a documentation paradigm that would create an environment of knowledge retention of the necessary skills needed to maximize the learning potential of the individual who operates the software, a review of the present research of the aspects of learning was conducted. The results of this review, as well as a review of the generally accepted statistical methods of data analysis and acquisition, combined with the current level and functionality of end-user documentation products resulted in the development of a world-wide survey of end-user satisfaction, desires, complaints, and needs concerning end-user documentation of commercially, and in-house, developed software products.

Lastly, combining the results of the survey questionnaire, the present known methods of improving learning skills, and the requirements of the Modified Foster Model resulted in the documentation paradigm for end-user documentation for products supported by a "Help Desk."

2.3 Statement of Contribution

It is clear from the many theses that have been submitted over the years that there are many areas in which the software maintenance activity can be improved upon. Studies, and papers, have been done on the effect that documentation has on a user's satisfaction with a software application; its ease of use, how quickly a user can learn to use the application, and on how documentation should be standardized. [GEMO90, GUIL89, WILE91, MITC94, DOUG93, JOHN93] None of these studies or papers focuses on the simple issue that, quite possibly, the documentation just cannot be read or comprehended by the typical user for one or more reasons.

The contribution of this thesis to the body of knowledge in software maintenance will be two fold. First, the construction of a model that incorporates existing theories of the software maintenance process, but concentrates upon improving the satisfaction of the end-user by enhancing the software documentation paradigm. This will be influenced by a study of the software maintenance process and consideration of the literature on documentation from both a computing and non-computing prospective. Secondly, through the introduction of an end-user software documentation product designed upon the desires and needs of the end-user. This will be influenced by a study

of the literature on how people learn and by carrying out an end-user questionnaire on the attitudes of documentation. The interplay of the influences on this research is articulated in Section 3.1 of this chapter.

The introduction of these two items will improve the software maintenance processes by limiting maintenance requests to "actual" problems with software, versus "perceived" problems caused by inadequate end-user documentation.

2.4 Criteria for Success

In evaluating the successfulness of this thesis, the following criteria were established:

1. Address, access, and identify the problems associated with end-user documentation.

2. Examine current models of the software maintenance process.

3. Develop, evaluate, and present a new model of the software maintenance process that incorporates end-user documentation.

4. Present an example of an end-user software documentation paradigm that meets the desires and needs of the end-user community.

Evaluation of these criteria will occur in Chapter 8.

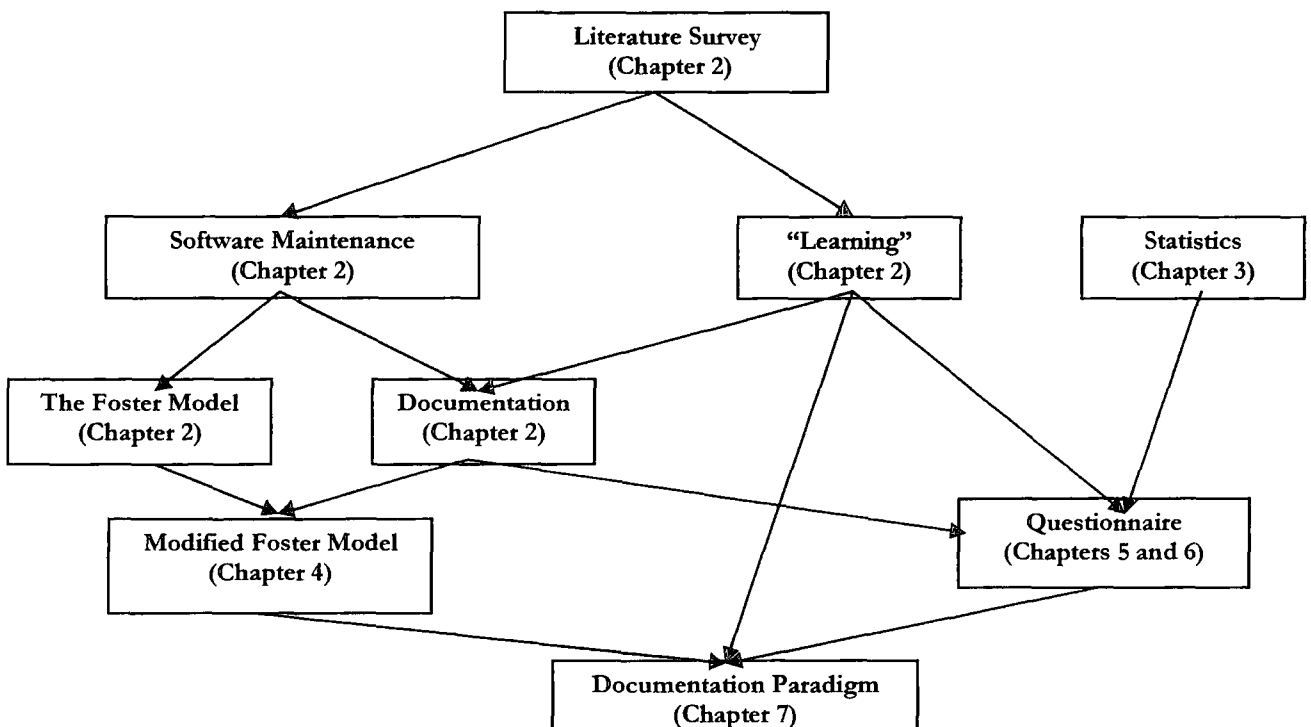
3. Thesis Overview

The remaining portions of this thesis are divided into the following chapters:

- Chapter 2 contains a survey of the current literature in the disciplines of software engineering, software maintenance, education and training, and educational psychology.
- Chapter 3 discusses the various statistical tools available for researchers, and how and when they are utilized.

- Chapter 4 revisits the Foster Model in detail and presents an addition to this model.
- Chapter 5 introduces the survey utilized in this research as well as discusses the demographical distribution of the respondents.
- Chapter 6 performs the statistical analysis of the data obtained from the survey.
- Chapter 7 presents an end-user software documentation model.
- Chapter 8 summarizes the conclusions of the author and suggests areas for further research.

Figure 1-1
Thesis Structure



Chapter 2

LITERATURE SURVEY

1. Introduction

A software product consists of three parts; the source code, programming documentation, and end-user documentation. [BLUM95] Software is a unique product. In theory, software should be the world's best product. Created in the minds of programmers, it is a product that could be, theoretically, created without defects. [LITTL92] Unfortunately, though, this is not the case. This product, like any other, must be maintained.

Research, conducted within the discipline of software engineering that specializes in software maintenance, has lead to the development of many new tools and procedures to improve the manner in which software is maintained. Unfortunately, this research has been directed primarily towards only one aspect of the software product, the computer source-code. Admittedly, some research has been directed towards improving software product documentation, but, again, the concentration of this research is towards developing tools to generate various forms of documentation that would assist the programming team in maintaining software. [CAPR92]

Concerning the third component, end-user documentation, of a software product, what research has been conducted on the maintenance or lack of maintenance of end-user documentation? From what appears in the literature of software engineering, virtually none. [AGAR96, MALL96, NARA98]

It is believed that this oversight on the part of researchers and practitioners in software maintenance has many serious repercussions. One such repercussion is the tendency, in general, of humans to blame technology in general, and software in particular, for any negative outcome during a human – machine interaction. [SAMP86, MORG92,

POST92, MOON98] The consequence of this repercussion includes, at a minimum, the lost productivity on the part of the programming team attempting to fix a "bug" that does not exist as well as the lost productivity of the end-user waiting for the programming team to correct this "bug."

2. Software Maintenance

The reasons why a programming team would modify software source code have been classified into between three [SWAN76] and five [GORL91] different categories. Each of these categories describes the purpose of the modifications implemented by a programming team. For the purposes of this document, the four classifications listed below will be used to describe what motivates a programming team to modify software: [PRESS92, BENN91]:

Perfective Maintenance: The alteration or modification of code so that it will conform to a new specification. This generally includes the addition of functionality to the code, but may include the removal of functionality from the code.

Adaptive Maintenance: The modification or alteration of code so that it will execute in a new or changed environment.

Corrective Maintenance: The modification or alteration of code to remove errors. In other words, making the code perform to original specifications.

Preventative Maintenance: The modification or alteration of the code without the removal or addition of any functionality or correction of errors. This is usually performed in an attempt to make

future maintenance tasks easier and less expensive to perform. [COOP93]

A good summary of the above classification structure would be the definition of software maintenance as proposed by the IEEE [IEEE84]:

> *The modification of a software product, after delivery, to improve performance or other attributes, or adapts the product to a new environment.*

In order for a software maintenance team to perform the tasks associated with the aforementioned definition of software maintenance, it is generally accepted that the maintenance team must become proficient in the following three areas [BLUM95]:

Application: This includes the ability to develop an understanding of the business requirement and how the software responds to and satisfies that business requirement. Since the most frequent request for maintenance will be to enhance (i.e., perfect) [LIEN80] the application, the programmer must be able to understand the intent of the change as well as any effects that the change may have on the application.

Software tools: This includes the programmer's proficiency with the programming language, software development tools (such as editors, compilers, and debuggers), analysis methods, and documentation tools.

Product: The actual software to be maintained. This includes source code, and programming and end-user documentation.

Although maintenance programming is generally considered as an inferior, non-creative, or boring assignment by most programmers, one that does not require

anything above an average intelligence or programming ability [LIU76], it can be shown that the opposite is true. Clearly, the maintenance team has a more difficult task than the original designer of the software. The maintenance team must be proficient in all three of the aforementioned areas; the original designer must be proficient in only two: the business application and the software tools. Additionally, the designer of a product is not constrained, as is the maintenance team. The maintenance team has no control over what design methods preceded them, whereas the designer can select and implement the design method of his choice. [FOST89] Often the maintenance team is forced to reverse engineer the product prior to performing the maintenance task in order to determine the original specifications or business requirement due to missing documentation. This reverse engineering, or actually the development of a more abstract concept of what the program is required to perform, is a major problem for maintenance teams. [BENN88] Clearly, program maintainability, or better stated, the maintenance team's ability to maintain the software, can be directly linked to how well the maintenance team understands the program; the more difficult the program is to understand, the more difficult it is to maintain. [BERN84, LANN94]

Most programmers who have ten years of experience have at least sixty percent of that experience in maintenance. [LIU76] Additionally, seventy percent of most applications exist on legacy systems. [GOFF94, DWIG94] According to a survey conducted by Lientz and Swanson, the mean distribution of effort expended on maintaining software applications in 487 data-processing organizations was [BENN91a]:

Figure 2-1

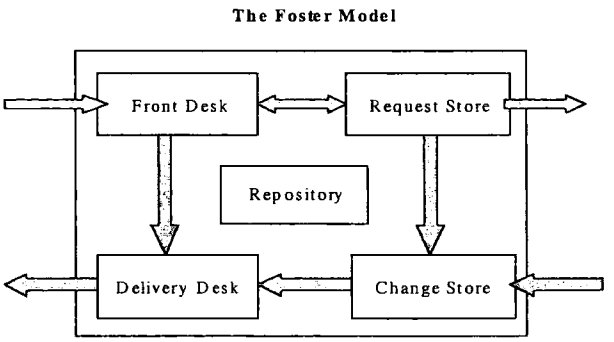
Maintenance Performed	Percentage of Effort
Perfective	50
Adaptive	25
Corrective	21
Preventative	4

What is not readily apparent, though, from all these statistics is the amount of maintenance performed upon software products due to poor, or inadequate, end-user documentation, nor the end-user's inability to use the software due to deficiencies in documentation.

2. 1 The Foster Model: The Front Desk and the Interface to the End User

In the model of the software maintenance team depicted in Figure 2-2, end-users submit requests to the Front Desk for assistance or maintenance on a software product supported by the team. [FOST93] If the maintenance team has the solution to the end-user's request readily available, the end-user immediately receives the solution through the Delivery Desk. If the Front Desk does not have the solution, the request is queued in the Request Store for further investigation by the maintenance team and the end-user is notified. Customers submitting requests to the Front Desk would prefer that this queue is empty at all times, but economics, staff availability, and prioritization of previously submitted requests usually prohibit this queue from being empty.

Figure 2-2



When a new request enters the Request Store, the management of the Request Store prioritizes it, after preliminary analysis and investigation, in relation to the severity of the request, the urgency of the request, and the current resource commitments. During the course of the preliminary analysis and investigation, the management of the Request Store may determine that the maintenance team does not possess the necessary resources, knowledge, or capabilities to satisfy the request. In any of these situations, the request is forwarded onward to the Front Desk that resides within the company or organization that is capable of satisfying the original request; in effect becoming the customer to a new Front Desk.

Once the maintenance team has developed, or has been provided with, a solution to the end-user's request, it deposits this solution into the Change Store, the repository for all software modifications. Notification of the availability of the modified software

product occurs after the maintenance team has recorded the modification and is provided to the end-user by the Delivery Desk.

Over the course of time, new editions of the software product, incorporating all of the available changes, perfections, and modifications, will become available. These new versions are held in the Repository and become available for dissemination or distribution to the customer.

Although there are many dimensions surrounding this model (e.g. the composition of the personnel of the Front Desk, maintenance staff, queued requests, and general end-user capabilities) it is believed that the omission of the maintenance issues of the end-user documentation on the part of researchers, and practitioners, in software maintenance has many serious repercussions. One such repercussion is the tendency, in general, of humans to blame technology in general, and software in specific, for any negative outcome during a human – machine interaction. [SAMP86, MORG92, POST92, MOON98] Since the end-user's satisfaction with software is the ultimate test of its usability [ARTH88], the consequence of this repercussion includes, at a minimum, the lost productivity on the part of the maintenance team attempting to fix a "bug" that does not exist as well as the lost productivity of the end-user waiting for the programming team to correct this "bug."

2.2 Defining Computer Documentation

Within the computer industry there appears to be no standard definition of what documentation should be included in the materials that are provided for the end-user with a software product. Numerous books and articles tell a potential software developer what *should not* be included, but very few describe what *should* be the minimal required set of materials to accompany a software product. Thus, to evaluate fairly and critique what is available on the market for the end-user, we must establish a baseline for what is meant by the term "documentation." For the purposes of this document the following definition will be used to define "documentation" [AMER92]:

> *The organized collection of records that describe the structure, purpose, operation, maintenance, and data requirements for a computer program.*

With the definition quoted above as a baseline, documentation for the end-user can be partitioned into several categories, each providing the end-user with information about the product, its functionality, and its requirements for operation. Although there appears to be no standard definition of what this partitioning is, or what it shout contain, the consensus is that end-user documentation should consist of the following items: a user manual, an installation guide, a configuration or customization guide, an error recovery or problem determination guide, a network or connectivity guide, and online help and tutorials [DENT93a, SPEA84, GOOD93]. The outline below demonstrates the categories into which end-user documentation can be partitioned and the various forms of information that each of these categories should provide the end-user:

User Manual

- The hardware, software, publications, and knowledge prerequisites.
- A brief description of the product and its functions.
- An overview of the product, and what you can do with it.
- An introduction to using the functions of the product.
- Starting and stopping the product.
- Using functions to accomplish the most common tasks.
- Using functions to accomplish less common tasks.
- Using functions to accomplish advanced tasks.
- Customizing a function.
- Understanding error messages and making the necessary corrections.
- Getting help with problems.
- A glossary.
- An index

Installation Guide

- Hardware, software, publication, and knowledge prerequisites.
- Upgrading from a previous version.
- Preparing the hard file.
- Installing product files.
- Complete or partial installation.
- Interrupting and resuming the installation.
- Error messages and recovery procedures.
- Testing the installation.
- A glossary.
- An index

Configuration or Customization Guide

- Hardware, software, publication, and knowledge prerequisites.
- A brief introduction to the product and the purpose of its configuration or customization tasks.
- The relationship between installation tasks and configuration or customization tasks.
- The advantages and disadvantages of configuring or customizing the product.
- The restrictions of the product.
- The tools provided for configuration or customization tasks.
- Making a backup copy of the original settings.
- Changing the default settings.
- Modifying common functions.
- Modifying advanced functions.

- Writing macros or routines so that end-users can modify small elements of the product.
- Restoring the original settings.
- Recovery from errors.
- A glossary.
- An index

Error Recovery or Problem Determination Guide

- Hardware, software, publication, and knowledge prerequisites.
- The notational conventions in error messages or return codes.
- A brief introduction to diagnosing problems and recovering from errors.
- The tools provided for problem determination and error recovery.
- Obtaining information about errors.
- Identifying the location, source, or environment of the problem.
- Classifying the problem by type.
- A list of error messages and recovery actions by type.
- Getting additional help.
- A glossary.
- An index.

Network or Connectivity Guide

- Hardware, software, publication, and knowledge prerequisites.
- A brief introduction to the product and supported connectivities.

- Planning for connectivities in similar and dissimilar environments.
- Planning for security on a network.
- The supported protocols.
- The tools provided for setting up the network.
- Host connectivity tasks.
- Controller and server connectivity tasks.
- Workstation connectivity tasks.
- Adding additional users to the network.
- Managing the resources of the network.
- Diagnosing and correcting problems in the network.
- Monitoring and tuning the network for performance.
- A glossary.
- An index.

Online Help and Tutorial

- An interactive multimedia description of the product and its functions.
- An interactive multimedia overview of the product, and what the user can do with it.
- An interactive multimedia introduction and tutorial on using the functions of the product.
- An interactive multimedia tutorial on using functions to accomplish the most common tasks.
- An interactive multimedia tutorial on using functions to accomplish less common tasks.
- An interactive multimedia tutorial on using functions to accomplish advanced tasks.

- An interactive multimedia tutorial on customizing a function.
- Understanding error messages and making corrections.
- Automated step-by-step instructions on solutions to performing tasks with the software product.
- An interactive hypertext linked glossary.
- An interactive hypertext linked index.

Depending upon the software product, each one of these categories of documentation may be provided to the end-user as a separate manual, several combined into one manual, or not provided at all. Interestingly enough and most likely erroneously assumed by the computing industry, recent additions to software, such as wizards and icons, are not considered part of the user-documentation according to the literature surveyed. Furthermore, without even a de facto standard on what documentation should be provided with a software product to the end-user, let alone what format in which it should be presented, leaves the question open as to what the standard documentation paradigm should be.

Considering all of the possible information available to the end-user on how to operate any given software product, the questions of why the average end-user has such a fear of using the computer, and its associated software must be asked. [SMIT96, CRIC83] Most likely it is because of one or more problems with the documentation that was provided with their software product.

2.3 Problems with Documentation

The end-user's satisfaction with software is the ultimate test of its usability. [ARTH88] Therefore it would be expected that there would be considerable research by the computer industry on how to create and maintain effective end-user documentation. However, there is very little literature available on the subject of end-user documentation production. [RATC87] Moreover, the following list summarizes the existing research on end-user documentation by the relevant authors [RETT91, DENT93, CHAR91, CRIC83, CROW92, GEMO90, COST99]:

I. End-users resist explicitly addressing themselves to new learning.

II. End-users are impatient learners and want to get started quickly on something productive.

III. End-users skip around in manuals and on-line documents and rarely read them fully. (Corollary: End-users reading the documentation to do a task refer to the documentation selectively and infrequently.)

IV. End-users make mistakes but learn most often from correcting such mistakes.

V. End-users are best motivated by self-initiated exploration.

VI. End-users are discouraged, not empowered, by large manuals with each task decomposed into its subtask minutiae.

VII. End-users will most likely consult another person, either a co-worker or a friend, on how to perform the desired task, rather than the documentation.

VIII. End-users find that computer documentation is too complex to understand to adequately make use of the application.

IX. End-users find that computer documentation is generally inaccurate or out-of-date.

X. End-users find that written computer documentation is too voluminous in order for them to quickly find the solution.

XI. Graphical interfaces, when considered as end-user documentation, have considerably improved human-computer interaction.

XII. End-user satisfaction with a software product can be greatly influenced by the documentation accompanying the software product.

XIII. There is a widespread dissatisfaction among end-users with the quality of existing manuals. [MANT83, NICK81]

XIV. A user manual is of very little value if the users cannot understand or follow its instructions. [ALLW97]

XV. A major problem with many conventional manuals seems to be that they focus more on the system, than on the users and their tasks, and thus they can be said to be designed in conflict with the users' primary goals which is to carry out their work tasks rather than read about how to do so. [CARR88]

XVI. Manuals, no matter how well written, are rarely used. [CARR88, PENR88, RETT91, SCHA83]

XVII. User manuals may not provide information in a form that the user can easily utilize [ALLW86, DRAP92, LEWI82] and this is a problem for novice users. [ALLW90]

XVIII. According to Carroll et al [CARR87] minimalist approach manuals which are short in length, task-oriented, and support error recognition and recovery, will help novice users to lean how to operate a computer in less time and with better skills than a conventional manual. Although the minimalist approach appears to be an effective method to end-user manual design that outperforms most traditionally produced manuals and is considered by some to be possibly the most important methodological contribution to documentation [ALLW97], some of its empirical claims have nevertheless been criticized and challenged by several authors. [BROK90, CHAR88, DRAP92, NICK91, TRIP90, WILL92]

Thus, for example, it would appear that a minimalist, graphically displayed, task-oriented documentation scheme would seem an important contributory factor in designing a new, and most likely successful, documentation paradigm for, and by, the computing industry. Interestingly enough, research conducted in other academic disciplines, which include business administration, psychology and education, concerning end-user documentation and training appears to have been overlooked by software developers and maintainers. Examples of this research have shown that:

I. Since man's ability to remember appears to be limited to seven items at a time, human beings can remember and process more information from a visual stimulus than from a written document. [MILL82]

II. The visual impact of the interface to the end-user is of vital importance. In essence, the end-user interface must be intuitive so that required documentation on the operation of the software product is either unnecessary or minimized. [AGAR96]

III. Interfaces that reflect experienced user knowledge will facilitate learning and increase productivity for users at all levels of expertise. [NELS87, MACDO88, DAVI93]

IV. In order to be effective to the end-user, and improve the end-user's learning and understanding of the software product, documentation should be task oriented, versus system oriented, and concise. [IRVI93, MATH93, SCHR93]

V. Although end-user training has been identified as a critical factor that can affect the success or failure of an end-user-computing tool in an organization, it is one of the first items to be cut from information technology budgets or taken for granted. [NELS87]

VI. User behavior has been said to be predicated upon user perceptions of the attributes of the target technology. [MOOR91, CREA95]

VII. End-user perceptions of software are a key element in its ultimate acceptance and use. [CHEN86, SCHR93]

VIII. Prior to the introduction of the personal computer, white-collar worker productivity was growing at an annual rate of 3.3%. By 1990, after an estimated one trillion dollars had been spent on technology based productivity tools, this figure had dropped to 1%. (In another study by the Gartner Group it was shown that white-collar worker productivity in 1987 was exactly at the same level it was in 1967 despite the huge investments by corporations in computers and integrated office systems.) [SIVU90]

IX. Discretionary users, who have the freedom to choose their own software, may reject software systems that are perceived as difficult to learn or use, or are of marginal usefulness. Even users who do not have a free choice of software may minimize their use of software packages that they perceive as being difficult to use or less useful. [BENB93]

X. Interaction style, or what is more commonly referred to as the user interface, is a prominent influence on end-user perception and performance. [WIED97]

XI. Governmental bodies and commercial industries achieved significant cost savings and improved end-user satisfaction and productivity when documentation for non-software products or services was simplified and made task oriented. These cost savings were achieved, among other things, through the reduction in staff associated with responding to requests for assistance by the end-user of the product or service and the reduced number of liability law suits and associated expenses. [SIVU90]

XII. It is important to design menus based on the language currently being used rather than on the linguistic traditions of the population using the interface [DONG99]

XIII. Lecturing is the *least* effective instructional method. [MEYE99]

XIV. Interactions with computers and information about computer processing are significant factors that effect user anxiety. [GALA83, TORK92]

XV. Several studies have shown that there is a widespread dissatisfaction among end-users with the quality of existing manuals and documentation. [ALLW97]

XVI. Labels and icons with labels are better than icons alone for a learner's ability to retain skills. Additionally, an interface designed with icons suggests ease of use to the learner and is rated easier to use partially independent of performance. [WEID99]

XVII. If training is to be successful, it must be cognizant of the user's attitudes toward computers. [ZOLT82]

XVIII. Training significantly improves the computer self-efficacy of both males and females. Training programs seem to be more effective for male and female respondents that have positive attitudes towards computers. Training programs seem less effective for individuals with negative attitudes toward computers. [TORK99]

XIX. A major problem with many conventional manuals seems to be that they focus more on the system than on the users and their tasks. Thus they can be said to be designed in conflict with the users' primary goal, which is to carry out their work tasks rather than to read about how to do so. [CARR88]

From comparing the two previous lists, it can be deduced that software developers and maintainers have overlooked what should be the primary function of software product documentation: to train, or teach, the end-user how to operate within the parameters of the software product to achieve the desired results. To this extent, the science of learning must be examined.

3. The Act of Learning

Learning, whether it is associated with a software product or not, has several variables that can affect an individual's ability to master a subject area. Examples of these variables, and associated research on their effects, are [HART98]:

A Fundamental Differences]:

- Age [SUTH97]
- Culture [MCNA97]
- Ability [WONG95]
- Sex [HAYE95]
- Introversion/ extroversion [EYSE85]
- Motivation [ABOU95]
- Anxiety [ZEID96]

B. Cognitive styles and ways of thinking]:

- Convergent / divergent [HART97]
- Reflexive / impulsive [GOLD96]
- Field dependent / independent [LIU94] (The ability to separate the "forest from the trees")
- Visualizers / verbalizers
- Abstract / concrete / active /reflexive [WILL96]
- Locus of control [MILL95]

C. Learning strategies]:

- Deep /surface approaches [SADL96]
- Serialist / holist [PATE95]
- Cursers / scanners [SANT85]
- Various study methods [CHAL96]

D. Preferences]:

- Prior knowledge and interest [TOBI94]
- Morning /evening persons [GREE95]
- Seating position [BURD96]

One or all of the aforementioned variables associated with learning can affect the effectiveness of software documentation. For example:

- In a study to point out that social contexts are important in determining what appear to be sex-related differences in learning, the same task was presented to boys or girls as either a measure of needlework or of electronics, the effect of the labeling was to reverse the direction of sex difference in the performance of the task. [ARCH96]
- Older people are faced with the expectations of their colleagues, friends, and family, on a daily basis, about what they can and cannot do – and eventually begin to underestimate themselves and their abilities. [HESS94, COLE93]
- An individual's ability to learn, and perform, a task is directly related to how similar they feel to the method of presentation or to the task itself. [MOON98]
- People assume more responsibility for outcomes, educational or otherwise, when they feel that they are in control than when they feel out of control. [RODI85]
- The type of user interface used with a software product will induce a learning mode of either explicit or implicit. Individuals learning in an explicit mode must have a conscious and selective attention towards a given subject, whereas learning through an implicit mode implies a trial and error approach. Direct manipulation devices, such as a computer mouse, are commonly associated with the implicit method of learning. Experiments have shown that the traditional definition of "user friendliness" does not automatically correspond to the best performance in terms of efficient learning. It has been suggested that user-friendliness be re-defined to focus on the quality of learning the product [SCHA96]

- Instruction, regardless of form, should not be tailored to one particular method of learning or learning ability for constant distribution. [AGAR96] Instruction should create a climate of collaboration between others. [TENN97] Ideally, training should be individualized to accommodate each individual's unique characteristics.
- Novices to a subject area require a feedback loop that informs them of errors and intentions, with intentions being viewed as what is the next step in the process. [HAAK99]
- Multimodal explanations are superior to unimodal explanations. [NARA98]
- Motivation and incentives play a large roll in the speed at which an individual learns, in particular a software product [AGAR96]
- People, in general, can recall material better, or in other words learn more easily, if more than one of the senses is stimulated during the process of learning. [TRUM98]
- Rote memorization is an ineffective approach to increasing memory for most individuals. With rote memorization the tendency is for an individual to remember the first and last items in the series of the items being memorized [TRUM98]
- For optimal learning, the items that are to be learned should be grouped into no more than 9 steps and no less than 5 steps, with 7 steps being the optimum. [MILL82]
- The more an individual feels in control of the situation the more quickly that individual will master the subject. [MOON98]
- Interactions with computers and information about computer processing are significant factors that affect user anxiety. [GALA83]
- Learners can remember and process more information from a visual stimulus than from a written document. [MILL82]

- According to Carroll et al [CARR88a] minimalist approach manuals which are short in length, task-oriented, and support error recognition and recovery, will help novice users to lean how to operate a computer in less time and with better skills than a conventional manual. Although the minimalist approach appears to be an effective method to user manual design that outperforms most traditionally produced manuals, some of its empirical claims have nevertheless been criticized and challenged by several authors. (Brockman [BROC90], Charney et al [CHAR88, CHAR90], Draper and Oatley [DRAP92], Nickerson [NICK91], Tripp [TRIP90], Williams and Farkas [WILL92])

From the information above about learning and the end-users known perceptions about end-user documentation, the study of the effects of end-user documentation on the maintenance process appears to be overlooked.

4. Summary

Unlike many other areas of software development, the area of software product documentation for the end-user is ill defined at best. Studies, and papers, have been written about the effect that documentation has on a user's satisfaction with a software application; its ease of use, how quickly a user can learn to use the application, and on how documentation should be standardized. [GEMO90, GUIL89, WILE91, MITC94, DOUG93, JOHN93] But, remarkably, there are, presently, no hard-fast standards for what should be, and what should not be, provided for the end-user in the terms of documentation.

Research has been performed by other academic disciplines on the manner in which people learn the effectiveness of learning, and the most effect method to present material for learning. This research does not appear to carry over into the development, or maintenance, of software products, and in particular, the development of end-user documentation. This is in spite of the fact that research within the

discipline of software engineering and its related fields has shown that an end-user's perception of a software product can be influenced by the documentation provided for the use of the software product.

5. Conclusions

Software maintainers, in research and practice, have been concentrating their efforts on only one component of the software product: the computer source code. Admittedly, this research has provided new tools to the industry that allow software maintainers to modify and document a software product's source-code in a quick and easy fashion. However, in doing so, they may have inadvertently overlooked the one area that may have improved their productivity, reduced the total amount of software modification requests, and improved relations with the end-user of the software product.

The user manual represents a major possibility for users to learn a new application program. It is frequently the primary, and sometimes the only, source of information available to the user both for instruction and when difficulties occur with the program. [WRIG83] But, documentation, and in particular the user manual in its present form, is inadequate for the end-user.

Chapter 3

STATISTICS REVIEW

1. Introduction

Statistics is a subject with a long antiquity, but short history. Statistics' antiquity can be traced back as far as to when Aristotle developed the taxonomy for the classification of animals. [HART96] But the history of statistics is beset with negative comments. Comments that imply that the sole purpose of statistics is to manipulate the situation under question, malign the fiction into truth, or conjure up evidence to support some theory or hypothesis. Examples of these negative comments include:

- The famous quote of Benjamin Disraeli, "There are three kinds of lies: lies, damned lies, and statistics." [TRIO98]
- General Charles H. Grosvenor stated, "Figures won't lie; but liars can figure." [RAO97]
- "If you torture the data long enough, they'll admit to anything." [TRIO98]
- Historian Andrew Lang claimed that some people use statistics "as a drunken man uses lampposts – for support rather than illumination." [TRIO98]
- Statistics has not yet aged into a stable discipline with complete agreement on foundations. [RAO97]
- Sir Joseph Stamp avowed, "The governments are very keen on amazing statistics. They collect them, add them, raise them to the nth power, take the cube root and prepare wonderful diagrams. But you must never forget that every one of these

figures comes in the first instance from the village watchman who puts down what he damn pleases." [RAO97]

- William Broad and Nicholas Wade once wrote," As more cases of fraud broke into public, and whispers were heard of others more quietly disposed of, we wondered if fraud wasn't quite regular minor feature of the scientific landscape." [RAO97]

In spite of such negative commentary, statistics has been hailed as the "guardian of the scientific method" [WEGM00] and has been adopted by virtually every major field of scientific inquiry as the method in which to convey truth, fact, and ideas. [RAO97a] The ubiquity of statistics, as it is now understood, studied, and practiced, extends through the whole gamut of natural and social sciences, engineering and technology, management and economics, art and literature. For illustration [RAO97a]:

- The layman uses statistics for decisions in daily life, making future plans, investments, or even for deciding where to live. Although the layman might not be fully cognizant of statistical methods and procedures, he is inundated with graphs and analysis from the media.
- The government utilizes statistics to make short and long range plans to implement economic and social goals. Sophisticated statistical techniques are used to make forecasts of population density, demand for consumer goods and services, and to formulate plans for desire growth in soci-economic growth.
- Scientific research utilizes statistics in the gathering of data, testing of hypothesis, estimation of unknown parameters, and in the interpretation of results. Without statistics, many modern scientific discoveries may never have happened; for example statistics played a vital role in the discovery of the Rhesus factor in blood groups. [FISH47]
- Industry uses statistical techniques to improve and maintain production quality levels. Experiments are conducted to

determine methods to improve the production quantity – in fact production has increased by 10% to 100% in industrial plants that utilize statistics without any further investment or plant expansion.

- Business utilizes statistical procedures to forecast future demand for goods, to plan production, and to implement and plan effective management techniques to maximize profits.
- Medicine utilizes statistical procedures for the acceptance of new medications for treating diseases, forecasting the spread of diseases, and perfecting medical diagnosis.
- Literature often seeks the advice of statistics to solve disputes about authorship of works or qualification of an author's style.
- Archeology utilizes quantitative assessment of discovered objects to place objects from antiquity in chronological order.
- Lawyers utilize statistical evidence, in the form of probability, to supplement oral and circumstantial arguments in courts of law.
- Law enforcement utilizes statistical procedures to analyze the available information, to piece together the available data, and to see underlying patterns in order to catch criminals.

In short, there seems to be no field of research, or human endeavor for that matter, that cannot be enhanced by injecting statistical ideas and methods into it. As C. R. Rao, one of the greatest contributors to statistical theory in the 20th century [WEGM00], has stated "It is apodictic to claim: If there is a problem to be solved, seek for statistical advice instead of appointing a committee of experts. Statistics and statistical analysis can throw more light than the collective wisdom of the articulate few." [RAO97a]

2. Statistical Data

Data gathered during research processes can be classified into one of the following data types: Nominal, Ordinal, Interval, and Ratio. A description of each of these statistical data types follows: [KVAN96]:

Nominal: Nominal data assigns labels, or numerical values acting as labels, to each data point collected. Examples of nominal data are the sex classification of subjects, such as Male or Female, or coding, such as 1 = Male and 2 = Female. The use of nominal data, or classification, can be traced back to Aristotle [HART96]

Ordinal: Ordinal data. arranges the data in some form of ranking scheme (e.g. Highest to lowest, worst to best, etc) Order of the values carries importance, but the mathematical differences of the values carry no importance or meaning. For example: 2 – 1 = 1 and 10 – 9 = 1, but this does not imply that 1 and 2 were just as close in the final results as were 9 and 10

Interval: Interval data places a significance and meaning upon the interval, or distance, between data points. With interval data the mathematical operations of addition, subtraction, multiplication, and division become meaningful. Temperature is the classic example of interval data. With temperature it is true that the difference in heat between 14 degrees Centigrade and 15 degrees Centigrade is the same as that between 30 degrees Centigrade and 31 degrees Centigrade. Classically, many of the techniques used to analyze data in statistics require data that are at least of this strength.

Ratio: Ratio data has a definite zero point, a point that indicates nothing exists for the variable being measured. Ratio data differs from interval data in that there is a definite zero point. An important distinction between interval data and ratio data is that for interval data, a value of zero is an arbitrary point and does not reflect an absence of the characteristic of interest. For example, the Centigrade temperature scale is interval, whereas the Kelvin temperature scale is ratio. On the Kelvin scale of temperature, the value of zero represents that all chemical activity has ceased to exist, whereas on the Centigrade scale, the value of zero represents only another temperature. Tests to determine if the data in question is ratio or interval include making the decision about whether twice the numerical value of one data point is actually twice as valuable as another data point. For example, on the Centigrade scale of temperature is 14 degrees twice as hot as 7 degrees? The answer to this question is "no," so therefore the data is interval, not ratio.

3. Methods of Gathering Data for Statistical Analysis

The methods of gathering data to analyze statistically can be classified into two broad categories: observational study or experimental. In an observational study observations or measurements of specific characteristics are made, but no attempt is made to manipulate or modify the subjects being studied. Whereas in an experiment some form of "treatment" is applied, then the researcher proceeds to gather data on the effects of the "treatment" upon the subjects of the research. [TRIO98]

"Treatment" is a very broad term, which can include the giving of experimental medication to subjects, or just asking subjects to use their left, then their right, hand to open a jar. As can be easily seen, any time the researcher induces some form of

modification upon the subjects of analysis the researcher is conducting an experiment. All other forms of data collection, such as counting the occurrences of an event or asking subjects to complete a questionnaire or survey, are classified as observational studies.

Regardless of which form of data gathering method is selected, certain key topics must be kept in the mind of the researcher, for data that has been carelessly collected may be so completely useless that no amount of statistical maneuvering or conjuring can salvage it or the researcher. The six most common methods of sampling populations are: Random Sample, Stratified Random Sample, Systematic Sampling, Cluster Sampling, Convenience Sampling, and Self-selected Survey [TRIO98]. Listed below are each of the sampling methods and a short discussion about the characteristics of each sampling method:

Random Sample

Members of the population are selected in such a way that each has an equal chance, or probability, of being selected. Additionally, a simple random sample of n subjects is selected in such a manner that every possible sample of size n has the same chance of being chosen.

Stratified Random Sample

The population is subdivided into at least two different subpopulations, or strata, that share the same characteristics. Once the stratification has been completed, a sample is drawn from each of the stratum.

Systematic Sampling

The population is placed into an unordered list. Next, a random starting point, called p, within the list is selected as well as an increment, called k. Sampling occurs selecting every $p + jk$ th item from the list where $j = 0$ to $n-1$, where n is the size of the desired sample.

Cluster Sampling

The population area is first divided into sections, or clusters, and then a random selection is made amongst the clusters. All members of the selected clusters are then sampled.

Convenience Sampling

Data is selected at the convenience of the researcher, which normally means that the researcher simply uses data that is readily available.

Self-selected Survey

The respondents select or chose themselves inclusion in the data being collected. Examples of this type of data collection method include the "900" telephone (where the caller has to pay a specified fee, generally $1.00 or above, to make the call) surveys conducted by American television news programs and "talk shows." This method is generally considered to be the least reliable method of collecting data, for generally speaking, only those individuals with strong opinions, either for or against, the topic of research will provide data.

When conducting an observational study, via a questionnaire or survey, great care must be given to the selection, wording, and ordering of the questions on the survey. Improper wording of surveys can drastically change the outcome of the survey. For example, when U.S. presidential candidate Ross Perot asked the question "Should the president have the line item veto to eliminate waste," 97% of the mail-in responses voted affirmatively. But, when the question was reworded to "Should the President have the line item veto, or not?" only 57% responded affirmatively. [TRIO98] This simple example demonstrates that researchers must take great care in ensuring that their questions are not biased because of being worded to elicit the desired response.

4. Methods and Procedures for Analyzing Statistical Data

The tools of modern statistical analysis, or hypothesis testing, can be traced back to two papers published in *Biometrika* by J. Neyman and E. Pearson. [NEYM28] In these papers the authors introduced the concept of choosing between two hypotheses, the

null and alternative, and the associated errors when rejecting these hypothesis, Type I for the null and Type II for the alternative, when the null hypothesis is true. A. Wald further expanded these methods in his book *Statistical Decision Functions* to what are now the orthodox methods for hypothesis testing within the statistical community. [HILL00]

In summary, modern hypothesis testing is conducted in the following manner [NEAV88]:

- **Step 1: Formulate practical problem in terms of hypothesis.**

  Any statistical test involves at least two hypotheses, the null, called H_0, and the alternative, called H_1 or H_A. The null hypothesis normally states that there is no difference, change, or, more simply, maintain the status quo. In essence, the null hypothesis is the standard, or control, against which the strength of evidence in favor of the type of difference described by the alternative hypothesis can be measured.

- **Step 2: Choose the test statistic.**

  Once the data has been gathered to test the hypotheses, the data must be reduced to some useable, manageable, form. The act of reducing the data into a useable form is called "creating a test statistic." Test statistics must possess the following properties in order to be useable in testing hypothesis:

  1. The test statistic must behave differently when the alternative hypothesis is true versus when the null hypothesis is true. In general, the greater the difference in the real situation from that expressed by the null hypothesis, the greater the difference should be in the behavior of the test statistic.

  2. The probability distribution function of the test statistic should be calculable under the assumption that the null hypothesis is true. Additionally, the probability distribution function must be

non-negative with a total area under the distribution function equal to one.

The power of a statistical test is its probability of rejecting the null hypothesis. Although two different test statistics may be utilized on the same set of data, it is always best to use the test statistic with the most power. [POLL77]

Step 3: Determine the critical region and value(s) for the test statistic.

Critical regions are the collection of values of the test statistic that strongly point to the alternative hypothesis being true rather than the null hypothesis being true. Critical regions are based upon significance levels, and can be different for each test statistic distribution. A *level of significance* is the probability of rejecting the null hypothesis when it is true, and is set by the researcher prior to conducting the hypothesis test. The *significance level* also signifies the probability of committing a *Type I Error,* rejection of the null hypothesis when the null should not be rejected. A *Type II Error* is committed when the researcher fails to reject the alternative hypothesis when the null hypothesis is true.

Critical regions are either *one-tailed* or *two-tailed.* A one-tailed critical region is used when the alternative hypothesis is directional in nature, such as greater improvement, less improvement, etc. A two-tailed critical region is used when the alternative hypothesis asks if there is any difference at all.

The *critical value* is the value, or values, that separate the critical region from the values of the test statistic that would not lead to rejection of the null hypothesis.

Step 4: Perform the test statistic upon the collected data.

Calculate the test statistic and compare the calculated result with the published critical values for particular significance levels for the null

distribution of the test statistic. Rarely must the researcher calculate the null distribution of the test statistic in order to calculate the critical values.

If the calculated test statistic falls within the published critical region, reject the null hypothesis. Otherwise reject the alternative hypothesis.

The choice of which test statistic to utilize partially depends upon the type of data the researcher has collected. Nominal and ordinal data, classified as non-parametric or distribution free data, require different test statistics than do interval or ratio data, which are classified as parametric. Due to the nature of the data collected as part of this research and the significant quantity of statistical tools available, only the statistical tools utilized in later chapters, or ones that are necessary to help clarify the tools that were used, will be discussed in detail in this chapter.

4.1 Parametric Test Statistics

Parametric test statistics utilize the mean, standard deviation, and variance of a sample or population to conduct hypothesis tests. The definitions of each of these follow [POLL77]:

Mean of a population:

$$\mu = \frac{\sum_{i=1}^{n} x_i}{n}$$

where :

μ = *population mean*

n = *population size*

x_i = *ith data element*

Mean of a sample:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where :

μ = *sample mean*

n = *sample size*

x_i = *ith data element*

Variance of a population:

$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n}$$

where :

σ^2 = *population variance*

μ = *population mean*

n = *population size*

x_i = *ith data element*

Variance of a sample:

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

where :

s^2 = *sample variance*

$\bar{x}$ = *sample mean*

n = *sample size*

x_i = *ith data element*

Standard Deviation of a population:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n}}$$

where :

σ = *population standard deviation*

μ = *population mean*

n = *population size*

x_i = *ith data element*

Standard Deviation of a sample:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n-1}}$$

where :

s = *sample standard deviation*

$\bar{x}$ = *sample mean*

n = *sample size*

x_i = *ith data element*

4.1.1 The Z - score Test

The normal distribution can be called one of the most important of all continuous probability distributions. [NEAV88a] The normal distribution very adequately

describes the distributions of many natural events, such as the distribution of the heights of individuals, the weights of individuals, and the actual amount of coffee received from a vending machine. The normal distribution is completely defined by the given population mean and population variance. The probability distribution function for the normal distribution defined by a given population mean and population variance is [POLL77] defined in Formula 3-1.

$$N(\mu,\sigma) = \frac{e^{-\frac{(x-\mu)^2}{2}}}{\sigma^2\sqrt{2\pi}}, \qquad -\infty < x < \infty$$

Formula 3-1

From this, one would assume that separate calculations would have to be made for each population mean and population variance in order to develop a proper test statistic. To preclude this from happening, the Z-score translates any data point, contained within any normal distribution to the normal distribution defined by a mean of zero and a standard deviation of one. The Z-score is thus defined as:

$$Z = \frac{x-\mu}{\sigma}$$

Formula 3-2

Distributions, and critical values based upon the distribution, for Z are published in many mathematical, physical science, and statistical textbooks and handbooks. As such, evaluation of this test statistic, as outlined in Section 4, becomes a trivial matter. Figure 3-1 demonstrates the standardized normal distribution that is found within these aforementioned textbooks.

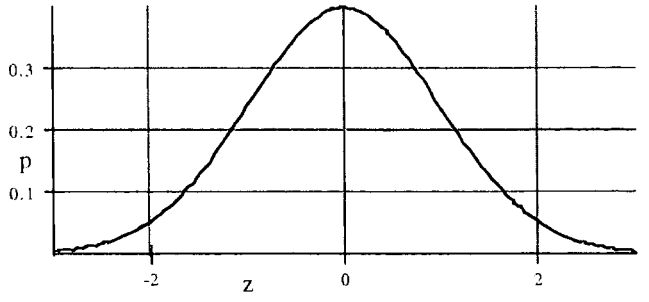


Figure 3-1

4.1.2 The Student t – Test

The t – Test was introduced by "Student" (the nom de plume of William Gossett [TRIO98]) in the early part of the 20th century as an aid to small samples' analysis in Guinness's Brewery in Dublin, Ireland. [UNWI00] Mathematically underpinned a few years after its introduction, it is now probably the most used, and misused, of all test statistics. [UNWI00]

The t-Test is based upon finding the critical region on the t distribution, which is defined in Formula 3-3. The t distribution depends upon the degrees of freedom of the sample data set. The value of the degrees of freedom parameter is one less than the size of the sample data set for single sample tests, and is two less than the sum of the sample data sets size for a two sample test. As Figure 3-2 demonstrates the t distribution for small degrees of freedom looks similar to the normal distribution in Figure 3-1 excepting that it has heavier tails. Since the t-Test is performed upon a sample, not the entire population, these heavier tails give more weight to the uncertainty of not knowing the overall population mean or variance. But, as can be seen in Figure 3-2, as the degrees of freedom grow larger, the t distribution approaches the normal distribution. In fact when the degrees of freedom approach infinity, the t distribution is the normal distribution. [POLL77]

$$f(x) = \frac{\Gamma(\frac{v+1}{2})}{v^{1/2}\Gamma(1/2)\Gamma(v/2)}(1+\frac{x^2}{v})^{\frac{-(v+1)}{2}}$$

where

$$v = \text{deg}\,rees\ of\ freedom$$

$$\Gamma(n) = \int_0^\infty e^{-x}x^{n-1}$$

$$for\ n \geq 0$$

Formula 3-3

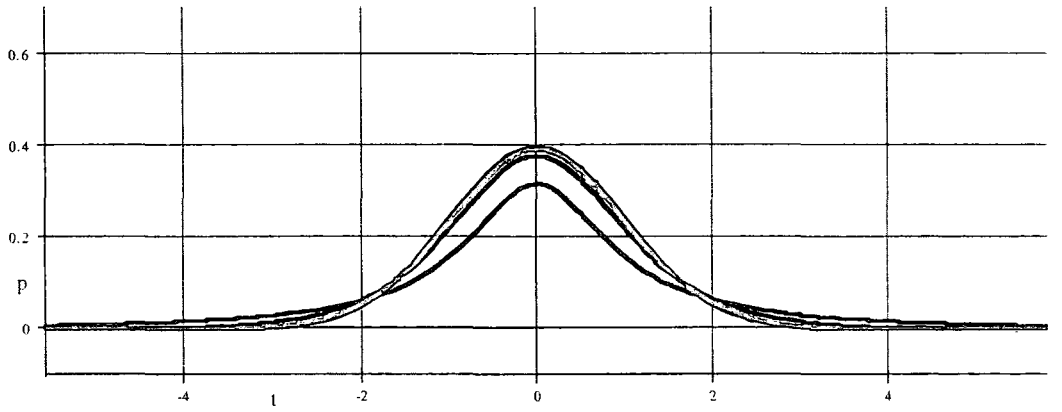


Figure 3-2

Prior to conducting a t-test, the researcher must ensure that the data collect meets the following conditions [POLL77, FINK90]:

- It must be assumed that the underlying population is normally distributed which implies that there is only one mode and the distribution is basically symmetrical.
- The samples should be small in size. Small, though, is a relative term. Some authors deem small to be less than or equal to 30 [TRIO98a] whereas others determine small to be just less than 1,000 data points. [POLL77, UNWI00]
- The overall population standard deviation is unknown.
- The overall mean of the population is unknown.

Hypothesis testing using the t-Test can be of two different forms. In the first form, the test can be used to compare two samples to see if they come from the same population or if one population has a mean greater than the other population. Figure 3-4 demonstrates the procedure used to calculate the t-score for comparison with the critical values described in Section 4. During the computation of the test it is generally assumed that the difference between the two population means is zero.

$$t = \frac{(x_2 - x_1) - (\mu_2 - \mu_1)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Formula 3-4

In the second form, called the matched pairs t-Test, the t-Test is used to compare "before" and "after" effects of some treatment, or if there is a difference between a matched sampling of "left handed people" and "right handed people." In order to conduct this test, the difference is calculated between the matched pairs of data points. After the difference is taken, the mean and sample standard deviation is computed for this new data set. Utilizing Formula 3-5, the researcher computes the t-score with the assumption that the overall mean would be zero (no difference between the "before" and "after" data sets). Computation of the critical value and region for this t-test is conducted as outlined in Section 4.

The t-Test is most frequently used for comparing the means of two samples. Although there might be many other interesting features for comparison, it is only the means that are analyzed. [UNWI00]

$$t = \frac{x - \bar{x}}{s / \sqrt{n}}$$

Formula 3-5

4.2 Nonparametric Test Statistics

Nonparametric tests are utilized when the assumptions for the parametric tests are not met, or when the researcher has data, such as nominal or ordinal, which cannot be analyzed by the parametric tests. Nonparametric tests make no assumption about the distribution underlying the data. Nonparametric tests have the advantage of not assuming normality, but they can be slightly less powerful than the parametric tests discussed previous. Excepting for the Chi-square test, each of the following nonparametric tests has a corresponding parametric test, and when the conditions of the parametric test are met, it behooves the researcher to utilize the parametric test, which in general, is more powerful. [POLL77]

4.2.1 Chi-square Test

Karl Pearson first suggested the Chi-square test in his paper "On the theory of contingency and its relation to association and normal correlation" published in 1904. [UPTO78] The test, although based on the Chi-square distribution as described in Formula 3-6 and demonstrated for several degrees of freedom in Figure 3-3, makes no assumptions about the distribution or type of data contained in the cross-tabulation, other than the data is randomly selected. Regardless of the data type, the Chi-square tests the null hypothesis that the row variable and the column variable are independent of each other.

$$p(x) = \frac{x^{\frac{v}{2}-1} e^{\frac{-x}{2}}}{2^{\frac{v}{2}} \Gamma(\frac{v}{2})}, \quad where \quad 0 \le x \le \infty \quad and \ v = \text{deg}ress\ of\ freedom$$

Formula 3-6

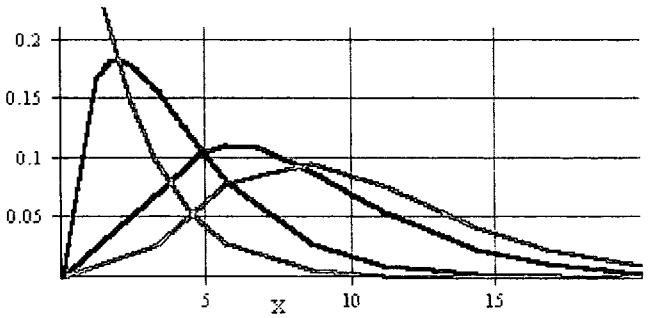


Figure 3-3

The computation of the Chi-square statistic is as follows [UPTO78]:

Step 1: For each row in the cross-tabulation, calculate the sum of all data elements in that row and place it at the end of each row. Call this value R_i.

Step 2: For each column in the cross-tabulation, calculate the sum of all data elements in that column and place it at the bottom of each column. Call this value C_j.

Step 3: Sum all of the row totals and call this total T. (This should equal the sum of all of the column totals.)

Step 4: Create the Expected Value matrix $E_{i,j} = (R_i C_j / T)$

Step 5: Compute the Chi-square statistic by $\chi^2 = \sum \frac{(O_{i,j} - E_{i,j})^2}{E_{i,j}}$, for all rows and columns.

Step 6: The critical value for Chi-square with *(r-1)(c-1)* degrees of freedom, where *r* is the total number of rows in the cross-tabulation and *c* is the total number of columns in the cross-tabulation, can be found within numerous mathematical handbooks and statistical texts and handbooks. It is important to note that in order for the Chi-square test to work effectively all cells in the cross-tabulation must have a minimum value of five.

Note: For cross-tabulations that contained cells that have frequencies less than five, the Fisher's Exact Test should be used. [UPTO78] Details of this test can be found in [UPTO78] and [POLL77].

4.3 Confidence Intervals

When estimating population parameters, such as the mean of the population, an interval estimate is normally given. This interval estimate, commonly known as a *confidence interval*, is stated with a specified probability that the interval contains the population parameter. Population parameters, such as the mean, standard deviation, proportion, variance, and matched pairs difference to name a few, can be calculated

quite simply for parametric data. [LARS00] Alternative approaches are available for calculating confidence intervals for medians. [SILV92]

Confidence intervals generally rely on the Central Limit Theorem, which states that for any large sample the underlying distribution of the sample mean is approximately normally distributed, are calculated as the population parameter estimate plus or minus a margin of error. [MOOR97] The margin of error is based upon the critical value that yields an area, equal to the confidence level desired, under the distribution centered on the population parameter. [MOOR97]

4.3.1 The Z Interval

The Z Interval confidence interval is used to calculate an estimate for the population mean whenever the population standard deviation is unknown and the sample taken is large (e.g. greater than 30 samples). [BRAS99] In Formula 3-7, which depicts the manner in which to calculate the Z Interval confidence interval, Z_c is the critical value on the Z distribution that corresponds to the area bounded by a Z-score of zero and the Z-score that contains the area equal to one-half of the confidence interval desired.

$$\bar{x} \pm Z_c \frac{s}{\sqrt{n}},$$

where

$\bar{x}$ = *sample mean*

s = *sample standard deviation*

n = *sample size*

Z_c = *Z score critical value*

Formula 3-7

4.3.2 The t Interval

The t confidence interval is used to calculate an estimate for the population mean whenever the population standard deviation is unknown and the sample taken is small (e.g. less than or equal to 30 samples). [BRAS99] In Formula 3-8, which depicts the manner in which to calculate the t Interval confidence interval, t_c is the critical value on the t distribution, with n-1 degrees of freedom, that corresponds to the area bounded

by a t score of zero and the t-score that contains the area equal to one-half of the confidence interval desired.

$$\bar{x} \pm t_c \frac{s}{\sqrt{n}},$$

where

$\bar{x}$ = *sample mean*

s = *sample standard deviation*

n = *sample size*

t_c = *t score critical value with* $n-1$ *degrees of freedom*

Formula 3-8

4.3.3 Estimate of Population Proportions

The Population Proportion Confidence Interval is used to calculate an estimate for the proportion of the population that possesses a specific characteristic, such as "gender" or "infected with a virus." Unlike the previous confidence intervals, the proportion interval relies upon the binomial distribution, with the desired characteristic being considered the "success." [BRAS99a]

In Formula 3-9, which depicts the manner in which to calculate the Z Interval confidence interval, Z_c is the critical value on the Z distribution that corresponds to the area bounded by a Z score of zero and the Z score that contains the area equal to one-half of the confidence interval desired. [BRAS99a] In order for this interval to be considered reliable, n must be sufficiently large such that $\hat{p}n \geq 5$ and $\hat{q}n \geq 5$. [MOOR97a]

$$\hat{p} \pm Z_c \sqrt{\frac{\hat{p}\hat{q}}{n}},$$

where

$\hat{p}$ = *sample proportion*

$\hat{q} = 1 - \hat{p}$

n = *sample size*

Z_c = *Z score critical value*

Formula 3-9

4.4 Inferences on Population Proportions

Inferences on population proportion are made when the researcher wishes to draw conclusions about a population based upon a sample proportion taken from that population or to compare two populations based upon a sampled proportion from each population. As such, these inferences can be classified into two categories: inference about a single proportion or inference about the difference between two proportions.

4.4.1 Inference on a Single Proportion Test

Inferences on a single proportion test, depending upon the Alternative Hypothesis selected, on whether or not the overall population proportion meets a certain criteria. To test the hypotheses that H_0: $p=p_0$, computer the Z statistic as described in Figure 3-10 [MOOR00].

In order to use this statistic, all of the following assumptions must be made, and if any is violated, a different statistic must be used:

1. The data are randomly selected from the population of interest.
2. The population is at least 10 times as large as the sample.
3. The sample size is large enough so that np0 >= 10 and n(1-p0) >10

Critical values based upon the distribution for Z are published in many mathematical, physical science, and statistical textbooks and handbooks. As such, evaluation of this test statistic, as outlined in Section 4, becomes a trivial matter.

$$Z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}},$$

where

$\hat{p} = test\ proportion$

$p_0 = sample\ proportion$

$n = sample\ size$

$Z = Z\ score\ value$

Formula 3-10

4.4.2 Inference on Two Proportions Test

Inferences on two proportions are used to compare two groups, such as men and women, and see if there exists a difference between these two groups. To test the hypothesis that $p_1=p_2$, compute the statistic as described in Figure 3-11. [MOOR99]

This test is used when the number of success and failures in each group is at least 5.

Critical values based upon the distribution for Z are published in many mathematical, physical science, and statistical textbooks and handbooks. As such, evaluation of this test statistic, as outlined in Section 4, becomes a trivial matter.

$$Z = \frac{p_1 - p_2}{\sqrt{\hat{p}(1-\hat{p})(\frac{1}{n_1}+\frac{1}{n_2})}},$$

where

$$\hat{p} = \frac{X_1 + X_2}{n_1 + n_2}$$

$p_x = sample\ proportion\ of\ sample\ x$

$n_x = sample\ size\ of\ sample\ x$

$Z = Z\ score\ value$

Formula 3-11

5. Conclusions

Researchers from all academic disciplines, in their desire to uncover knowledge, gather data. But what conclusions can be made from the data that these researchers have gathered? Although statistics has a shady past, and many skeptics, it appears to be the art mutually accepted by researchers of all academic disciplines that allows them to make inferences and draw conclusions from data that they have collected.

This data, however, could be imperfect; imperfect in the sense that the data may convey useful information, but only reveal a portion of the whole story. [SIEG96] Care should be taken by the researcher to ensure that his data is collected properly without bias or prejudice. Proper statistical methods should be used in all parts of a

study or experiment from beginning to end. Once the data have been collected, the proper statistical tools should be used to ensure that as much useful information as possible is used to create results that have the greatest chance of increasing knowledge. [SIEG96] The researcher must, in addition to care taken while developing and implementing their research project, ensure that any report of the data be prepared without bias or prejudice; for example bias, and prejudice, can be introduced with the misuse of statistical graphs, plots, and charts in reports. [TRIO98]

As such, statistics is an art based upon mathematical principles. An art in that the choice of an inappropriate graph or tool may unjustly persuade the audience of the report in the direction that the author wishes, or in the completely opposite direction.

6. Summary

Statistics, now a sub-specialty of the Mathematical Sciences, is a subject with a long antiquity but short history. The history of statistics is beset with negative comments. Comments that imply that the sole purpose of statistics is to manipulate the situation under question, malign fiction into truth, or conjure up evidence to support some theory or hypothesis. In spite of such negative commentary, statistics has been hailed as the "guardian of the scientific method" [WEGM00] and has been adopted by virtually every major field of scientific inquiry as the method in which to convey truth, fact, and ideas. [RAO97a] The ubiquity of statistics, as it is now understood, studied, and practiced, extends through the whole gamut of natural and social sciences, engineering and technology, management and economics, art and literature.

Data, which can be analyzed by statistical methods, can be classified into two major categories: parametric and non-parametric. Based upon the category, different tools are used to test hypothesis, provide estimates for population parameters, or predict trends.

Chapter 4

THE MODIFIED FOSTER MODEL

1. Revisiting The Foster Model

Although research has been performed on various methods to improve the manner in which software source-code is maintained, it is not readily apparent that research has been performed on methods to circumvent the end-user from submitting false requests to the maintenance team. Revisiting the Foster Model of the software maintenance team depicted in Figure 4-1, end-users submit requests to the Front Desk for assistance or maintenance on a software product supported by the team. [FOST93] If the maintenance team has the solution to the end-user's request readily available, the end-user immediately receives the solution through the Delivery Desk. If the Front Desk does not have the solution, the request is queued in the Request Store for further investigation by the maintenance team and the end-user is such notified. Once the maintenance team has developed a solution to the end-user's request, notification is provided to the end-user by the Delivery Desk of the availability of the modified software product after the maintenance team has recorded the modification. The goal, of any organization, it would appear is to improve the responses time, or more succinctly, provide quick solutions to the end-user for maintenance requests.

Although it has been stated that training of end-users is very expensive [MALL96], there does not appear to be any research on the amount of time expended by software maintenance teams tracing down false problem reports due to inadequate training of end-users or due to poor documentation. Software maintainers may have overlooked possibly one of the simplest, yet probably the most effective, ways in which to improve software performance, even if it may be only virtually in the perception of the end-user. Most software maintainers may not agree with this statement, but consider the following questions:

1. Is incorrect or outdated operational documentation causing the end-user to do something that makes the system fail or deliver incorrect results?

2. Is incorrect or outdated user documentation causing data entry problems that result in processing errors?

3. What effect does the end-user possessing incorrect or outdated user's manuals have on the frequency and quantity of the submissions of maintenance requests on a software product?

4. What effect does responding to unnecessary maintenance requests have on the productivity of the software maintenance team?

5. If maintenance requests where reduced by the improvement of end-user documentation, could staff now work on the development of backlogged requests for new software?

6. How many requests for new software are based on the end-user's inability to utilize current software? (In corollary, what would the cost savings be if these requests for software development were nullified?)

7. What organizational cost savings and productivity could be incurred if end-users were able to quickly find the solution to their software problem? (Corollary: Could the Help Desk staff be reduced or re-utilized if end-users felt that they could utilize their documentation quickly and effectively?)

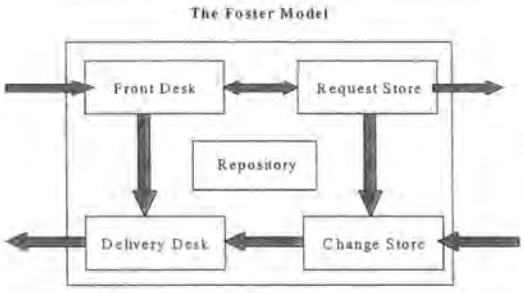


Figure 4-1

2. The Modified Foster Model

Suppose now that Foster Model is modified as in Figure 4-2. In this modification of the Foster Model, the Front Desk now becomes an interactive, real-time, documentation source for the end-user, with actual software maintenance requests for modifications or corrective action passed through the rest of the model. Although the Foster Model can be chained together multiple times with the Request Store of one model accessing the Front Desk of another model and the Delivery Desk providing responses to the Change Store of the preceding model, the Front Desk / IDP is now directed towards the ultimate end-user; the individual who is utilizing the end product software, such as Microsoft Word. As such, for the purpose of this discussion, the - user is defined as the individual at the far left terminal end of the chain of Foster Models.

The Modified Foster Model

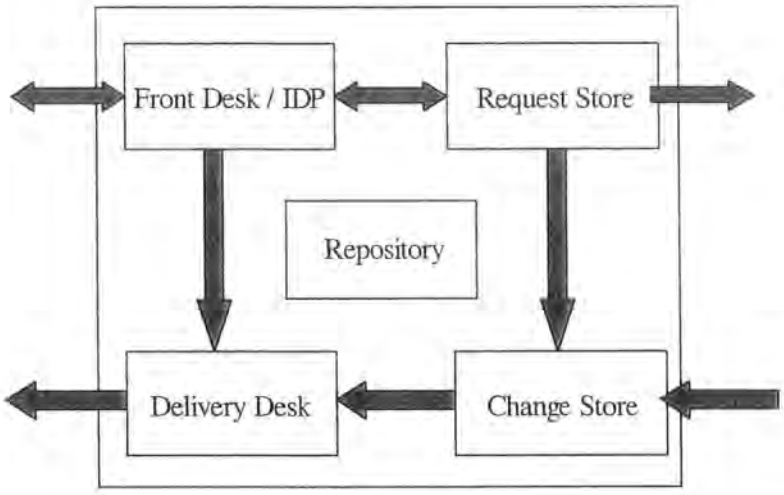
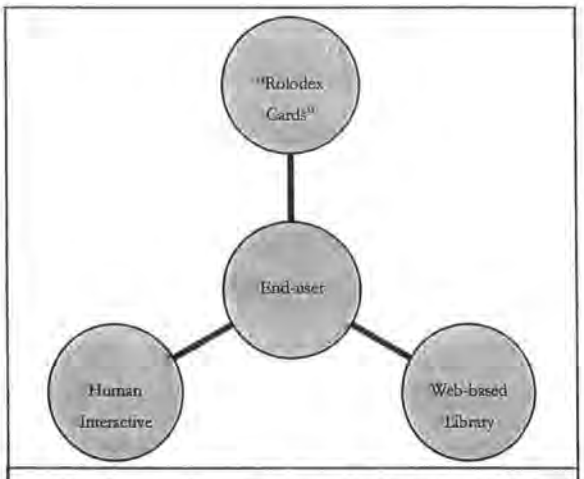


Figure 4-2

Individuals accessing the Front Desk / IDP may have already received training on the use of the software product, or may not have received training on a software product prior to accessing the Interactive Documentation Program (IDP). As such, the IDP makes no assumptions on the training level of the individual seeking assistance on the software product. Conventional end-user manuals, no matter how well written, are rarely used, [CARR88, PENR88, RETT91, SCHA83], and as such, will be totally omitted from the IDP portion of the Front Desk / IDP.

The foundation premise of the IDP is to capitalize on the research conducted on the psychological aspects of learning, as discussed in Chapter 2, in respect to end-user documentation and existing research on how end-users presently use documentation. Figure 4-3 depicts how the end-user can interact with the IDP. As can be seen in the diagram, the end-user has three choices on how to interact with the IDP: either total human interaction, via the Internet or web, and, lastly, via a personal library of "index cards." The overall goal of the IDP, regardless of the manner in which the end-user accesses the IDP, is to provide a standardized set of responses on how to perform tasks within the software product to the end-user community in as a concise manner as possible.



End-user Interaction With The IDP

Figure 4-3

Since it has been shown that end-users are more likely to consult another person, either a co-worker or a friend, on how to perform the desired task instead of looking through documentation [DENT93], the goal of the IDP's human interactive portion is to become the "friend of choice" and thus the source of assistance. Assistance provided to the end-user by the human interactive portion of the IDP will be either direct-to-the-terminal via a networked software package, such as Virtual Network Computing by ATT Cambridge Laboratories, which allows the IDP staff member to remotely demonstrate to the end-user on the end-user's computer system the necessary tasks, or the end-user will physically come to the IDP for private tutorial. If the mode of assistance is via a networked software package, the end-user will be in concurrent telephone contact with the staff member of the IDP who is providing assistance. The key feature of this portion of the IDP is that the networked software package allows the IDP staff member to physically control the end-user's computer systems as they explain the necessary tasks to the end-user, thus capitalizing on the research that has shown that people, in general, can recall material better, or in other words learn more easily, if more than one of the senses is stimulated during the process of learning. [TRUM98]

Individuals selected to staff the human interactive portion of the IDP must, in addition to being an expert on the software application, be professional educators trained on the

different methods and styles of adaptive learning, and be of a friendly personality. End-users who access this portion of the IDP will be asked if they desire the link to the web portion of the IDP for future reference, or if they would desire an "index card" containing the steps, for future reference.

Research, dating back to the 1950's, has shown that human beings cannot remember more than seven items, plus or minus two, at any given time [MILL82], and as such, any text-based documentation provided by the IDP to an end-user will have no more than seven simple tasks or steps, plus or minus two. All text-based documents, provided to the end-user by the IDP, will be either via the web or on "index cards," either electronic or physically capable of insertion into a Rolodex-type card holder, for easy search and retrieval by the end-user at a later date. Regardless of the form, either printed or hypertext, all documentation provided by the IDP will be single task oriented and concise. An example of the printed documentation is contained in the appendices.

Examining the text-based portion of the IDP shows that this documentation form differs dramatically from present forms of printed documentation. First, all instructions are concise, direct, and completely task oriented. Secondly, the web-based portion, although similar in some respects to current offerings, allows the end-user to quickly find solutions to the task-at-hand by following hyperlinks. Lastly, and essentially the most important feature of the text-based portion of the IDP, the "index card" feature allows the end-user to organize the steps associated with performing tasks in the software product in a manner that is personalized to their own form of "thinking," and as such, will allow for quick retrieval by the individual end-user when the need arises. For examples, suppose an individual desires to have the last five "index cards" used, or most frequently used, sorted alphabetically at the "top" of their "stack" of "index cards." Or, conversely, suppose that an individual desires to have their "index cards" sorted according to complexity of operation, with the simplest operation being first. Or, even yet, suppose that the individual desires to have the "index cards" just sorted alphabetically. As can be seen, the number of possibilities is as numerous as the number of individuals that will use this documentation method.

Empirically speaking, it appears that one of the main problems with current printed documentation is that the material is organized in a fashion that may be hard for the end-user to find the solution to the task at hand. This organization includes using terminology that the end-user may or may not understand or terminology different to what the end-user may describe a specific task as being. Allowing the end-user to organize the task sheets provided by the human interactive portion of the IDP allows for each end-user to create customized documentation packages; packages that can be expanded at any time to include any additional feature of the software product, or features of multiple software products, in their own terminology and desired volume. As research has shown, end-users find that written computer documentation, in its present form, is too voluminous in order for them to quickly find the solution. Thus, under this scenario the end-user is in complete control of the volume, content, and organization of the end-user documentation. Features of the software product that the end-user will never use will not appear in the individual end-user's personal documentation store. Documentation on features of the software product that the end-user rarely uses can be accessed either via the web, or via the human interactive portion of the IDP.

Visualization of this portion of the IDP can be achieved as follows. First, the end-user approaches the human interactive portion of the IDP for assistance on how to perform a specific task. The human interactive portion of the IDP can provide direct assistance as discussed earlier, direct the end-user to the web page, provide "index cards," or any combination of the preceding. "Index cards" that are provided in electronic form, either by electronic mail or media, are for insertion into a database, either physically located on the end-user's computer systems, or preferably on a portable electronic organizer-like device. "Index cards" that are provided in physically printed form are for insertion into a Rolodex-type cardholder to be placed beside the end-user's computer system.

As some individuals list contact names by first name in their personal telephone directory, others by last name, and still others by business associations, end-users can thus insert these "index cards" into their database in a manner that is personalized to their needs and thought processes. This will place the end-user in control of the

organization, form, and layout of their documentation package, and as such, the more an individual feels in control of the situation the more quickly that individual will master the subject. [MOON98] Furthermore, since the organization of the end-user documentation is individualized according to the thought processes of the individual end-user, search and retrieval of information for the individual end-user will be expedited. Lastly, the end-user, once confident on the procedures on performing a specified task, can remove the "index card" from their personal documentation store, reducing its volume, and simplifying future searches for task procedures.

If an end-user wishes information about additional features of the software product, or a different software product, the end-user can approach their "friend," the interactive portion of the IDP, for assistance on these additional features at any time. Their "friend" can then provide them with the requested information, either interactively for one-time basis assistance, or provide assistance and an "index card" for insertion into the end-user's personalized documentation store for future reference.

In summary, the IDP will transform the present written end-user documentation, which research has shown to be inadequate and non-productive for the end-user, into an interactive, personalized, end-user proactive learning procedure. Current methods of developing user manuals provide information in a form that the user can not easily utilize [ALLW86, DRAP92, LEWI82] which is a problem for novice users [ALLW90], and may be the reason why research has shown that end-user manuals, no matter how well written, are rarely used. [CARR88, PENR88, RETT91, SCHA83] With all documentation provided by the IDP being task oriented, short, and concise, according to present research the effectiveness to the end-user, and the end-user's learning and understanding of the software product, should significantly increase. [IRVI93, MATH93, SCHR93] As such, the IDP could alter end-user's perceptions about the software product, improve end-user productivity, and standardize intra-organizational end-user software product documentation. This can be achieved by the IDP, for it removes one of the major problems with many conventional manuals; they all seem to be focused more on the system, than on the users and their tasks, and thus they can be said to be designed in conflict with the users' primary goal which is to carry out their work tasks rather than read about how to do so. [CARR88]

3. Realizing the IDP (Genesis of the Hypotheses)

Does the need for an IDP actually exist? Research, conducted within the discipline of software engineering that specializes in software maintenance, has lead to the development of many new tools and procedures to improve the manner in which software is maintained. Unfortunately, this research has been directed primarily towards only one aspect of the software product, the computer source-code. Admittedly, some research has been directed towards improving software product documentation, but, again, the concentration of this research is towards developing tools to generate various forms of documentation that would assist the programming team in maintaining software. [CAPR92]

As can be interpreted from the description of the IDP in Section 2 of this chapter, the main purpose of the IDP is to circumvent the end-user from submitting a false maintenance request to the maintenance team. It is not readily apparent that research has been performed on methods to circumvent the end-user from submitting false requests to the maintenance team. To evaluate the need for, the viability of, and the possible benefits and success of the IDP the following 25 hypotheses were developed. The hypotheses are partitioned into five different categories, as follows: Perceptions of the problem; Perceptions of the end-user on end-user documentation; Are current documentation methods causing maintenance problems?; Current problems with end-user documentation; and, Education and training issues surrounding end-user documentation.

Detailed discussions for each of the hypotheses follow.

3.1 Perceptions of the Problem

What research has been conducted on the maintenance or lack of maintenance of end-user documentation, the third component of a software product? According to what can be found in the literature, there appears to be virtually no research conducted on this topic. [AGAR96, MALL96, NARA98] Why would the software maintenance and

development community overlook such an important feature of a software product? Thoughts on this subject lead to the formation of the following hypothesis:

> **Hypothesis 1:** Individuals employed within the computer industry will claim that current software practices concerning end-user documentation are adequate for the end-user, and that end-user documentation is well developed.

Research conducted in the field of software engineering has shown that the end-user's satisfaction with software is the ultimate test of its usability. [ARTH88] Since the currently accepted definition of software product includes end-user documentation [BLUM95], this leads one to ponder if the end-user is actually satisfied with the product that they are receiving in terms of end-user software documentation.

> **Hypothesis 2:** End-users as a group will signify that their over-all satisfaction level with end-user documentation is very low.
>
> **Hypothesis 3:** End-users, in general, will claim that end-user documentation for major products is inadequate for their needs.

As can be seen, Hypothesis 1 is diametrically opposed to Hypotheses 2 and 3. If all three hypotheses were not rejected during a statistical analysis of data obtained, this would demonstrate that the software engineering community has overlooked a very important area. As such, the software development and maintenance communities could significantly increase the perceptions of the end-user towards their product if they were to devote more energy to the development, and research, of end-user documentation.

3.2 Perceptions of the End-User on End-User Documentation

End-user perceptions of software are a key element in its ultimate acceptance and use. [CHEN86, SCHR93] Several studies have shown that there is a widespread dissatisfaction among end-users with the quality of existing manuals and documentation. [ALLW97] What are the current perceptions of the end-user concerning end-user documentation?

Hypothesis 4: End-users perceive that documentation management is inadequate.

Hypothesis 5: End-users believe that software manufacturers treat end-user documentation as an after thought.

Hypothesis 6: The majority of individuals will believe that software manufactures purposely develop bad end-user documentation.

Hypothesis 7: The majority of individuals will believe that vendor-supplied end-user documentation does not help them significantly.

Hypothesis 8: Removal of printed end-user's manuals from the documentation suite will have the least effect on the end-user productivity, as perceived by the end-user.

Hypothesis 9: The majority of individuals will believe that vendors purposely create an after market of additional books and materials for software products.

The end-user's satisfaction with software is the ultimate test of its usability. [ARTH88] Therefore it would be expected that there would be considerable research by the computer industry on how to create and maintain effective end-user documentation. However, there is very little literature available on the subject of end-user documentation production [RATC87], and it appears that nothing has changed since 1987. Could it be that the simplest way to improve end-user's perceptions and minimize maintenance requests is to totally restructure end-user documentation?

3.3 Are Current Documentation Methods Causing Maintenance Problems?

Studies, and papers, have been done on the effect that documentation has on a user's satisfaction with a software application; its ease of use, how quickly a user can learn to use the application, and on how documentation should be standardized. [GEMO90, GUIL89, WILE91, MITC94, DOUG93, JOHN93] None of these studies or papers focuses on the simple issue that, quite possibly, the documentation just cannot be read or comprehended by the typical user for one or more reasons. Does the problem of inadequate end-user documentation actually cause maintenance problems?

Hypothesis 10: An end-user's ability to utilize a computer system is hampered by current end-user documentation methods, techniques, and schemes.

Hypothesis 11: The majority of individuals will believe that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation.

Hypothesis 12: Given that the above hypothesis is confirmed, end-users will then report the "bug" to a "Help Desk."

Since the Tower of Babel, the problem of which language to use to record transactions or interactions between or within cultures has plagued mankind. During the Middle Ages, Latin was used as *the lingua franca* for recording the interactions between and amongst the merchant, governmental, and religious classes; and as such, virtually all important documents were developed in this universal language. [DUCK96] With the *lingua franca* of the Middle Ages not being one for all of the people, just a select few, the general populace could not understand this documentation, and a situation developed similar to that of today: a separation of classes based on the ability to process technical information with the poor becoming poorer because they are unable to process or understand this information. [FIEL94] The development of a systematic way of conveying information about computer applications to all people, regardless of educational level, is clearly necessary to correct this situation.

3.4 Current Problems with End-user Documentation

Psychologists have shown that human beings can remember and process more information from a visual stimulus than from a written document, since man's ability to remember appears to be limited to seven items at a time. [MILL82] Do current documentation methods require the end-user to attempt to remember too many steps at any given time?

Hypothesis 13: Current end-user documentation has too many steps to easily remember.

Educational researchers and psychologists have determined that the more an individual feels in control of the situation the more quickly that individual will master the subject. [MOON98] Additionally, they have determined that interactions with computers and information about computer processing are significant factors that affect user anxiety. [GALA83] As such, do the current practices of software documentation development and maintenance significantly contribute to the end-user's anxiety about the software application, and as such, become a detriment versus an asset?

Hypothesis 14: Although the primary function of a respondent's job is dealing with a computer system, they will generally feel unconfident about their skills.

Hypothesis 15: End-users fear a new release of software because of the learning curve.

Research has shown that software systems which are perceived as difficult to learn or use, or are of marginal usefulness may be rejected by discretionary users, who have the freedom to choose their own software. Even users who do not have a free choice of software may minimize their use of software packages that they perceive as being difficult to use or less useful. [BENB93] What socioeconomic impact is this having on society? Could the implementation of the IDP induce individuals to use software that would not normally use the software?

Further research has shown that governmental bodies and commercial industries achieved significant cost savings and improved end-user satisfaction and productivity when documentation for non-software products or services was simplified and made task oriented. These cost savings were achieved, among other things, through the reduction in staff associated with responding to requests for assistance by the end-user of the product or service and the reduced number of liability law suits and associated expenses. [SIVU90] Could the same be true for software products if the IDP were implemented?

3.5 Education and Training Issues Surrounding End-User Documentation

Research has shown that lecturing is the *least* effective instructional method. [MEYE99] Yet, other research has shown that training significantly improves the computer self-efficacy of both males and females. [TORK99] Does this imply that the end-user perceives that instructor-lead courses are more effective than current documentation methods?

Hypothesis 16: End-users will say that they find instructor-lead classes to be more effective than current documentation methods.

In corollary, current research has demonstrated that end-users will most likely consult another person, either a co-worker or a friend, on how to perform the desired task, rather than the documentation. Does this research still apply to an Internet-savvy generation of end-users?

Hypothesis 17: The vast majority of the user community will admit that they utilize the resources of a friend or an associated before they attempt to utilize a software package's user documentation.

Hypothesis 18: Printed documentation would be the least missed, of all of the user-documentation methods, if omitted from a software product.

Learning, whether it is associated with a software product or not, has several variables that can affect an individual's ability to master a subject area. [HART98] Research has shown that age [SUTH97], culture [MCNA97], and gender [HAYE95] affect the manner in which an individual learns a subject area. How do these apply to the development of end-user software documentation?

Hypothesis 19: As a group, individuals over the age of 50 will find computers, and associated documentation, harder to deal with and comprehend.

Hypothesis 20: As a group, the individuals between the ages of 10 and 35 will find the computer easier to deal with, and understand the associated documentation.

Hypothesis 21: Common-day software applications, such as Automated Teller Machines, which are supposed to be self-documenting systems, will on the most

part, be more difficult to use by older individuals, where older is age greater than or equal to 50.

Hypothesis 22: American idiomatic phrases have a significant impact on end-users ability to understand and utilize end-user documentation.

Hypothesis 23: As a group, women will find documentation harder to understand and utilize than men will. (Corollary: Gender specific terminology will have an impact.)

Research has shown that the type of user interface used with a software product will induce a learning mode of either explicit or implicit. Individuals learning in an explicit mode must have a conscious and selective attention towards a given subject, whereas learning through an implicit mode implies a trial and error approach. Direct manipulation devices, such as a computer mouse, are commonly associated with the implicit method of learning. Experiments have shown that the traditional definition of "user friendliness" does not automatically correspond to the best performance in terms of efficient learning. Furthermore, it has been suggested that user-friendliness be re-defined to focus on the quality of learning the product. [SCHA96] Other research has shown that instruction, regardless of form, should not be tailored to one particular method of learning or learning ability for constant distribution. [AGAR96] Instruction should create a climate of collaboration between others. [TENN97] Ideally, training should be individualized to accommodate each individual's unique characteristics.

Additionally, according to Carroll et al [CARR88a] minimalist approach manuals that are short in length, task-oriented, and support error recognition and recovery, will help novice users to lean how to operate a computer in less time and with better skills than a conventional manual. Although the minimalist approach appears to be an effective method to user manual design that outperforms most traditionally produced manuals, some of its empirical claims have nevertheless been criticized and challenged by several authors. (Brockman [BROC90], Charney et al [CHAR88], [CHAR90], Draper and

Oatley [DRAP92], Nickerson [NICK91], Tripp [TRIP90], Williams and Farkas [WILL92]). But are these challenges to task-oriented documentation justified, either in the perception of the end-user or in fact?

Hypothesis 24: End-users will signify that Goal/Objective oriented end-user documentation will increase their satisfaction with software products.

Hypothesis 25: The average person will state that the documentation supplied with game-oriented software is easier to comprehend and utilize than that of "standard" application packages, or will not need to use it at all.

Research has shown that a major problem with many conventional manuals seems to be that they focus more on the system than on the users and their tasks. Thus they can be said to be designed in conflict with the users' primary goal, which is to carry out their work tasks rather than to read about how to do so. [CARR88] Designers of software games, it empirically appears, tend to design their documentation synchronously with the end-user's goal: carry out a specific task. Could the software engineering community develop documentation for all products in this manner?

4. Summary

When man first decided to start painting on the side of his cave to instruct other tribal members on the migratory patterns of animals, tell a religious story, or recount historical tribal events, the art of documentation was born. These simple pictures allowed the tribe to share information via the use of symbols commonly understood, and thus easily read, by all tribal members. Even in today's modern world, many of these ancient petroglyphs still convey a basic message to the people who visit the locations on which they are painted.

As man became more civilized over the eons, civilizations developed and the need to convey and record information, other than the basic information of where food or

water may be found, became a necessity for the sufficient function of the civilization. During the course of the growth of the civilization of man, methods of interchanging information gradually moved from a pictographical to a hieroglyphical style; then to a logographical style; and finally to the alphabetical style in use today. This movement allowed the conveyance, to people around the world, of highly abstract concepts, such as mathematics, chemistry and physics, which have no real world symbolic representation. [WHIT95] With the advent of the ability to convey and record, actually document, abstract concepts, civilization became more technological.

As technology developed, so did man's need to convey and document even more abstract concepts and ideas. Concepts, ideas, and techniques that must be conveyed so that individuals who read the documentation can successfully perform complex tasks repeatedly. As such, a learning process must exist. Simultaneously, in the realm of software engineering, this learning process must increase the end-users' perception of the software product.

Earlier in this thesis it was discussed how end-users refer to an application's documentation only when necessary. From this, the logical conclusion that they are referring to the manual for one of two reasons can be drawn: either they forgot how to perform a task, or they are learning how to perform a task. Since end-user satisfaction with a software product can be greatly influenced by the documentation accompanying it [GEMO90], a method to improve end-user documentation is desired. The proposed method adapts the Foster Model, based upon several hypotheses about learning and present perceptions and practices in software end-user product documentation, to become an interactive, real-time, documentation source for the end-user, with actual software maintenance requests for modifications or corrective action passed through the rest of the model.

Evidence from the literature is that end-user documentation is a major problem and that this is causing the maintenance team unnecessary problems and work. Improving the Front Desk activity in the Foster Model will mean less problem requests get passed to the maintenance team. It is anticipated that the IDP would, in addition to minimizing the number of maintenance requests submitted to the maintenance team,

significantly improve the end-user's perceptions of the software product by reducing their anxiety. As such, it is anticipated that use of the IDP would significantly increase use of the software product and reduce overall maintenance costs of the organization operating the IDP.

Chapter 5

DEMOGRAPHICS

1. The Survey and its Methodology

Utilizing the Internet to gather scientific data is not a new idea. A psychologist used the Internet to gather data via the Internet to show that an addiction problem exists with the use of the Internet. This survey was conducted via the use USENET newsgroups by the author posting questions and receiving e-mails from the respondents. The author received 496 voluntary responses to her questions, but it is impossible to know how many individuals read her questionnaire due to the nature in which the USENET newsgroups function. [YOUN98]

Based upon the premise that the vast majority of users of software in the modern world would have access to the Internet, a web-based questionnaire was developed. This questionnaire, a sample of which is included in the appendices, inquired from the respondents certain demographic information in addition to inquiring about the opinions of the respondent on current software documentation practices and software documentation desires of the end-user. All data collected via this survey can be categorized as either ordinal or nominal in nature. Free response answers to the questionnaire were not permitted, although several individuals sent e-mails to the researcher commenting on the research being conducted. Responses that are appropriate are included in the appendices for reference only.

When conducting a survey via a questionnaire, which is statistically classified as an observational study, great care must be given to the selection, wording, and ordering of the questions on the survey, especially when the scope of the survey is world-wide. Improper wording of surveys can drastically change the outcome of the survey. To ensure that wording would have as little impact on the results of the questionnaire, all American idiomatic phrases were removed in addition to repeating several questions

throughout the survey worded slightly differently to ensure that the same response was achieved for the same type of question.

To ensure statistical randomness, 300,000 e-mail addresses were purchased from E-Mail Barn, Inc., an organization that assured that they provided "working" e-mail addresses to individuals worldwide. After receiving the e-mail addresses, a mass mailing of the message contained in the appendices was conducted. Of the 300,000 e-mail addresses that were purchased, 51,432 turned out to be no longer in use or invalid, leaving 248,568 e-mails that were actually transmitted to individuals.

Individuals that chose to take the survey were directed to the web page http://www.phdresearch.org/survey/survey1.cgi, which contained a PERL CGI script as a front end to the mySQL database that collected the data. Realizing that certain individuals could have a bias, either for or against, surveys of this nature or software documentation practices, the PERL script deposited a "cookie" on each computer system that took the survey. If that computer system attempted to take the survey again, the PERL script denied access to the survey and displayed a "thank you" message to the individual along with the current percentage responses for each of the survey questions. This method, it could be argued, is self-limiting the responses to the survey. If multiple individuals shared a computer system that had access to the Internet, only the first individual would be allowed to participate in the survey. Additionally, the PERL script was designed to allow responses during a specified four-month period of time; any individual attempting to participate in the survey after the ending date of the survey was denied access. This was instituted to insure data reliability and data integrity.

805 individuals responded to the survey. It cannot be determined if these individuals were recipients of the e-mail invitation to participate in the survey, or if someone who received an invitation directed them to the survey. Although this is a voluntary response survey, as are most surveys conducted in the modern world, it is felt that the responses to the questions are the unbiased response of the respondent and that controls were put in place to minimize data corruption.

2. Demographics of Respondents

Appendix 2 contains a series of tables and charts that depict the demographics of the survey respondents. Summarized below is the essential demographic information about the respondents to the survey. References to specific tables are not made, so the reader is encouraged to examine the tables and charts in the appendix.

2.1 Sex

555 (68.9%) of the 805 respondents to the survey were male and 250 (31.1%) were female.

2.2 Age

The tables in the appendices depict the age distribution of the respondents. Interesting age characteristics of the respondents are:

A. The age of respondents ranged from pre-teenager to over 90 years old.
   - The oldest respondent was female, as were the youngest.

B. The majority of the respondents were young.
   - 335 of the 805 respondents, or 41.61%, where between the ages of 20 and 35.
   - 421 of the 805 respondents, or 52.30%, are under the age of 35.
   - Thirty-four of the 805 respondents, or 4.22%, where over the age of 65.
   - The distribution of the ages in not normal, and is skewed to the right.

2. 3 Region Where Respondents Live

The majority of the respondents live on either the North American or European continents, with 597 of the 805 respondents, or 74.16%, living on the North American continent and 108 of the 805 respondents, or 13.41%, living on the European continent.

2.4 Native Language of Respondents

665 of the 805 respondents claimed that some form of English was their native language, with 67.45% of all respondents claiming that American English was their native language. Those that claimed that some form of English was their native language were not limited to the North American or European continents as depicted in the appendix. Interestingly, 725 of the 805 respondents, or 90.06%, felt that American idiomatic phrases would have an impact on non-native American English speakers. This opinion was true regardless of sex or where the respondent lived.

2.5 Education

The educational level of the respondents ranged from having a primary school education to having an earned academic doctorate. 484 of the respondents, or a total of 60.12%, had at least an undergraduate university education.

2.5.1 Educational Level

Educational level of the respondents varied according to region, sex, and academic discipline. Interestingly, the highest number of academic doctorates who responded to the survey had pursued the natural sciences.

- Educational level of the respondents varied according to the region where the respondent lived.
    - 57.45% of those who live on the North American continent have achieved at least an undergraduate university education.
    - 0% of those who live on the Central American continent have achieved at least an undergraduate university education.
    - 100% of those who live on the South American continent have achieved at least an undergraduate university education.
    - 70.37% of those who live on the European continent have achieved at least an undergraduate university education.]
    - 85.29% of those who live on the Asian continent have achieved at least an undergraduate university education.

- 50% of those who live on the African continent have achieved at least an undergraduate university education.
- 64.70% of those who live in Australia / New Zealand have achieved at least an undergraduate university education.
- 100% of those who live in the South Pacific Islands have achieved at least an undergraduate university education.
- 35.71% of those who live in a geographical area not mention in the survey have achieved at least an undergraduate university education.

- Educational achievement varied according to academic discipline.
  - Two academic disciplines, the natural sciences and the psychological sciences, had 100% of their respondents achieve at least an undergraduate degree. The subgroup with the highest level of education was those respondents who had pursued the natural sciences.
    - The subgroup with the largest number of doctorates, either academic or professional, was the natural sciences.
  - The academic discipline that had the highest percentage of respondents not achieving an undergraduate university degree was the computer sciences, with 24 of the 107, or 22.43%, not having obtained the degree at the time of the survey.
- 140 of the 250 women, resulting in 56% of the total women who responded, had at least an undergraduate education.
  - 56 of the 250 women, resulting in 22.40%, had received at least a Master's degree.
  - Women earned none of the academic doctorates in computer science.
- 344 of the 555 men, resulting in 61.98% of the total men who responded, had at least an undergraduate education.

- 140 of the 555 men, resulting in 25.22%, had received at least a Master's degree.

- 307 of the 484 respondents, or 63.43%, who had at least an undergraduate education had taken some form graduate education.
  - 196 of the respondents, or 24.24%, had received at least a Master's degree.
  - 80 of the respondents, or 9.94%, had received some type of doctorate, either professional or academic.

2.5.2 Academic Discipline of Respondents

316 of the 805 respondents, or 39.55%, had some formal training in engineering, the natural sciences, medical sciences, or computer sciences. 107 of the 805 respondents, or 13.29%, had formal training in the computer sciences. For those with formal training in the computer sciences, 36 of the 107, or 33.64%, had at least a Master's degree.

The predominant number of respondents, 291 out of 805, or 36.49%, claimed to have no formal training in any of the academic disciplines surveyed.

Respondents with formal training in the psychological sciences comprised the least number of responses of any academic group at 24, yet all of these 24 respondents had at least an undergraduate university degree, making them one of the most formally educated subgroup of the respondents. The subgroup with the highest level of education was those respondents who had pursued the natural sciences. Interestingly, this group had the highest number of academic doctorates.

2.6 Employment

395 of the 805 respondents, or 49.07%, have some involvement with the computer industry, either in the maintenance, development, instruction, or operation of computer software, hardware, and / or documentation. Of those involved with the development of software documentation, two individuals had an academic doctorate,

both of which were male[1], and neither was in the computer sciences. Interestingly, six of the twenty-three individuals, or 26.09%, involved with software documentation had not completed an undergraduate university education. Additionally, 16 of the 23 individuals, or 69.57%, involved with the development of software documentation claimed that American idiomatic phrases would not, or might not, have an affect on those individuals whose native language is not American English. Lastly, only two individuals involved with the development of software documentation had formal training in the computer sciences.

2.7 Where Respondents Use Computers

The majority of the respondents, 429 out of 805, or 53.29%, signified that they primarily use the computer at home and at work. This trend was remained true regardless of the region, educational level, or native language of the respondent. Only two individuals, or 0.24%, of the respondents used computers solely at school, and a total of 62, or 7.70%, did not use the computer within the home. Lastly, 16.77%, or 135 respondents, used computers in their home, work, and at some educational institution.

18.80% of the females who responded to the survey use the computer solely at home, versus 13.15% of the males who responded to the survey. Only one male and one female use the computer solely at school.

2.8 Computer Games

In respect to the playing of computer games, only 104 of the 805 respondents, or 12.92%, claimed that they never use the computer to play games. Some other interesting demographical information is:

- Respondents under the age of 21 always have some game use with computers.

[1] This is not readily apparent from the tables in the appendix. The chart created by the statistical software package SPSS could not be reformatted in a manner that would be presentable in this thesis.

- Of those respondents with an academic discipline, computer scientists make the most use of the computer for playing games.
- Only 35 of the 250 females, or 14%, who responded claimed that they never used the computer for playing games. Additionally, only 69 of the 555 males, or 12.43%, who responded claimed that they never used the computer for playing games.
- Age, and academic achievement, does not appear to have a bearing on whether or not the respondents used the computer to play games.
- Of the 104 respondents who did not use the computer to play games, 61.54%, or 64, where native-American English speakers.
- 343 of the 805 respondents, or 42.61%, found that the documentation with computer games was either unneeded or better than the documentation that is supplied with other computer applications.

2.9 Difficulty Using Automated Teller Machine

Only 8 of the 805 respondents to the survey, or 0.99%, have difficulty using Automated Teller Machines. There appears to be no connection between age, academic discipline, or academic achievement on the ability to use an Automated Teller Machine.

2.10 Views on Software Documentation

Views on software documentation range from the difficulty of using the documentation to whether or not there is a planned after-market for training materials. Views of the respondents are as follows:

- 603 of the 805 respondents, or 74.90%, found that software documentation was comprehensible most of the time.

- Academic doctorates had the highest percentage of difficulty with software documentation.
- Those respondents with academic training in the Letters had more difficult, on a percentage basis, with software documentation than other academic disciplines.
- 501 of the 805 respondents, or 62.23%, felt comfortable to extremely comfortable with a computer, yet 747 of the 805 respondents, or 92.80%, felt that improving software documentation could or would improve their ability to use a computer. Interestingly, 581 of the 805 respondents, or 62.24%, claimed that computer usage is a primary function of their work.
- 499 of the 805 respondents, or 61.99%, are likely to either read some or none of the supplied documentation before they utilize a software product, whereas 462 of the 805 respondents, or 57.39%, purchased some sort of after-market materials to assist them with the operation of the software product.
- People with an undergraduate college education or higher claimed that they purchased after-market materials more than those without an undergraduate education or higher.
- 533 of the 805 respondents, or 66.21%, believe that there is a possibility, or a reality, in software manufacturers purposely providing inferior documentation in order to purposely create an after-market.
- 507 of the 805 respondents, or 62.98%, felt that software documentation could be or is an after thought of the software producer, and 408 of the 805 respondents, or 50.68%, felt that the documentation was of little or no use at all.
- 664 of the 805 respondents, or 82.48%, feel that gender specific terminology does not have an effect on their use of a computer product. But, 23.2% of the female respondents felt that gender specific terminology affected them.
- 710 of the 805 respondents, or 88.20%, believe that menu based software packages help them.

- Only 47 of the 805 respondents, or 5.84%, felt that more examples with pictures of the expected result in software documentation would not help them, and only 25 of the 805 respondents, or 3.11%, felt that a more intuitive user interface would not improve their productivity.
- 360 of the 805 respondents, or 44.72%, do not report "bugs" to a Help Desk. For the 302 of the 805 respondents, or 37.52%, who do report "bugs" to a Help Desk, they generally wait for more than one business day to receive assistance or a solution to their problem.
- Only 174 of the 805 respondents, or 21.61%, are likely to call a friend when they encounter a problem with software.
- 430 of the 805 respondents, or 53.42%, felt that they were satisfied to extremely satisfied with vendor or developer supplied end-user documentation.
- 131 of the 250 females, or 52.40%, felt that they were satisfied to extremely satisfied with vendor or developer supplied end-user documentation, and 299 of the 555 males, or 53.87%, felt that they were satisfied to extremely satisfied with vendor or developer supplied end-user documentation.

3. Summary

Over the course of a three-month period, a survey of end-users was conducted over the Internet. 300,000 invitations to participate in this survey were disseminated via electronic mail, with a total response of 805 individuals, the preponderance of which was male. Individuals that responded to the survey came from all corners of the world, but the majority of the respondents were from the North American continent. Respondents ranged in age from pre-teen to over ninety years old, covered the full spectrum of academic preparedness and disciplines. Although the predominant native language was English, either American or United Kingdom, numerous respondents indicated other native languages.

A significant majority of the respondents to the survey consider themselves comfortable to extremely comfortable on the user of a computer. Yet, satisfaction by

the end-user with current documentation practices was a very slight majority, and the majority of respondents felt that if documentation were to be improved, their productivity would increase. Interestingly, academic doctorates had the highest percentage of difficulty with software documentation.

Chapter 6

THE STATISTICAL ANALYSIS

1. Introduction

As discussed in Chapter 2, a software product consists of the source code, programming documentation, and end-user documentation. Research conducted within the discipline of software engineering that specializes in software maintenance has lead to the development of many new tools and procedures to improve the way in which software products are maintained. Unfortunately, this research has been directed primarily towards only one aspect of the software product, the computer source code. Admittedly, some research has been directed towards improving software product documentation, but, again, the concentration of this research is towards developing tools to generate various forms of documentation that would assist the programming team in maintaining software. Unfortunately, the third component of a software product, the end-user documentation, appears to have been overlooked by those individuals specializing in software maintenance.

A key component of Chapter 2 is that research by other individuals within the discipline of software engineering has identified that the end-user's satisfaction with software is the ultimate test of its usability. [ARTH88] From this point alone it would therefore be expected that there would be considerable research on how to create and maintain effective end-user documentation by the computer industry. From a self-preservationist point-of-view, this would seem to be a very logical conclusion; the easier a user finds the software to use, the more likely they are to request the programming team to develop new software. (In corollary, without the end-user utilizing the software, there really is no need for the programming team to exist.) However, as discussed in Chapter 2, there is very little literature available on the subject of end-user documentation production.

The goal and objective of this research is to begin to fill the present void left by other researchers. The hypothesis of this research is that improved end-user documentation, and maintenance of that documentation, will tend to improve the productivity of the end-user, and as such, reduce overall software maintenance requests. In general terms, the overall objective of this research was to develop an improved scheme of end-user documentation.

As discussed in Chapter 5, to ascertain the perceptions of the end-user community, 300,000 invitations to participate in a survey on end-user documentation were distributed world-wide via electronic mail on the Internet. Since the survey was worldwide in scope, an attempt was made to standardize and generalize the questions. As such, no mention was made of any specific software product or computer system, and no idiomatic phrases were used in the development of the questions.

For the purposes of this survey, end-user software documentation was defined to the respondents as anything that can, or will, assist the end-user in the operation of the software product. As such, the following are all considered end-user software documentation: Printed user manuals, Icons, Wizards, On-line Help, and, Internet-based documentation. Respondents were encouraged to keep this definition in mind while they participated in this survey.

The survey consisted of 50 questions, a copy of which is in the appendices. All questions were in the form of either Yes/No, multiple choice, or on a numerical scale from 1 to 10. For those questions on a numerical scale, only whole number responses were accepted. For multiple-choice questions, the respondents were asked to please select the choice that best described, or most applied, to their situation. The questionnaire software only accepted a single response from multiple-choice questions.

Respondents were assured that all responses to the survey would be kept strictly confidential. As such, there was no form in which the respondents could supply any identifying information. Several respondents, did however, choose to email the researcher with comments. Comments suitable for publication are included in the appendices.

1.1 Survey Pros and Cons

Conducting a survey of this scope and magnitude has the potential for many problems to occur, as well as some drawbacks. Individuals not familiar with statistical techniques may question the validity of the survey, or the method in which the survey was conducted. Prior to the first invitation being transmitted electronically, the following pros and cons were debated on the merits of the survey. It is believed that the pros significantly outweighed the cons, and that the data collected signifies, statistically, the views of the end-user community.

1.1.1 Cons

Legitimate criticism of the survey can include the following:

1. Since the survey was randomly sent to 300,000 e-mail addresses around the world, and the survey participants submitted their results via the Internet, it is possible for a single person to have submitted multiple survey forms, despite the fact that precautions were taken to prevent this from occurring.

2. It was possible for the survey, in theory, to receive greater than a 100 percent response, since there was no true access control on the survey questionnaire, and respondents could direct other uninvited individuals to participate in the survey.

3. The survey method shows a slight bias in that it was distributed to individuals that are more computer-literate than the general public. It is believed that individuals with e-mail and Internet access would tend, as a group, to be more computer literate than those who do not have the same access would.

4. Since the survey was developed in American English, this could show a slight bias against non-native American English speaking people.

5. Since the survey was only offered in American English, without translation capabilities to other languages, this artificially limited the respondents to only

those individuals who could communicate in the various forms of the English language.

1.1.2 Pros

Conversely, supporters of the survey can argue:

1. Since the survey was distributed to individuals, that as a class are more computer literate, their exposure to computer documentation will be greater than that of the general public. As such, their responses should tend to be more forthright, since they have a vested interest in the improvement of end-user documentation.

2. Distribution of the survey invitations via the web allowed for a greater population to be survey at a far-reduced overall cost.

3. Distribution of the survey invitations via the web ensured that users of more than one computer platform, operating system, and software manufacturer were surveyed.

4. Statistically speaking, with such a large population to survey, if individuals submitted more than one response, the overall impact to the survey will be minimal.

2. Testing the Hypotheses

For each of the following hypothesis, the significance level of 5% was selected as the point at which to either reject the null hypothesis or fail to reject the null hypothesis. Admittedly some statistical Type I errors, rejecting the null hypothesis when the null should not be rejected, may occur at this level of significance. This level of significance was selected along the generally accepted principles of statistics used in the engineering, accounting, and business communities.

Additionally, as outlined in Chapter 5, the vast majority of data collected via the survey was either ordinal or nominal in nature. As discussed in Chapter 3, collection of such data minimizes the number of statistical tools available for analysis, and as such, only a select few of the statistical tests discussed in Chapter 3 were applicable for use in this research. All analysis performed in this chapter, and all charts, tables, and diagrams in the appendices, was conducted with the statistical software packages SPSS (Releases 10.0.7 and 11.01), and Minitab (Version 13), both of which are available from the University Information Technology Help Desk.

Following are each of the hypotheses from Chapter 5 analyzed independently. As a reminder, the hypotheses are partitioned into five different categories, as follows: Perceptions of the problem; Perceptions of the end-user on end-user documentation; Are current documentation methods causing maintenance problems?; Current problems with end-user documentation; and, Education and training issues surrounding end-user documentation.

Later in this chapter a complete analysis will be conducted on the relationship between these hypotheses and the IDP.

2.1 Perceptions of the Problem

2.1.1 Hypothesis 1

Individuals employed within the computer industry will claim that current software practices concerning end-user documentation are adequate for the end-user, and that end-user documentation is well developed.

Statistics Used:	Inference on a Single Proportion Test
Survey Questions Used:	Questions 31 and 33.
Tables and Diagrams:	Table 6-H1-1, Graph 6-H1-1, and Graph 6-H1-2

Question 31 inquired of the respondents their involvement in the computer industry. 152 of the 805 respondents had some involvement in the computer industry as outlined in Table 6-H1-1. Question 33 inquired of all respondents how they would rate the software industry on the overall design and implementation of end-user

documentation. Graph 6-H1-1 depicts the distribution of the responses of the individuals who are connected with the computer industry in bar chart form. Restructuring the responses into two categories, with an answer of 5 or less implying that the individual perceives that the development of software product documentation is an afterthought, and responses of 6 or greater are perceived as the respondent does not think that the development of software product documentation is an afterthought of the developer, we get Graph 6-H1-2. An Inference on a Single Proportion Test was conducted on the following hypothesis:

Null:	$p = 0.5$
Alternative:	$p > 0.5$
	Where p is the proportion of respondents that replied 1 to 5 on Question 33.

This test has a Z-score of 3.41, with a p-value of 0.00. Thus, the null hypothesis is rejected. As such, it can be concluded that the majority of software developers and maintainers consider software product documentation an afterthought of the development process.

2.1.2 Hypothesis 2

End-users as a group will signify that their over-all satisfaction level with end-user documentation is very low.

Statistics Used:	Inference on a Single Proportion Test
Survey Questions Used:	Question 24, limited to those who answered 7 on Question 31.
Tables and Diagrams:	Table 6-H2-1, Graphs 6-H2-1 and 6-H2-2

Question 24 of the survey inquired from the respondents their general satisfaction with end-user documentation. Table 6-H2-1 depicts the responses from those individuals not involved with the software industry, with the distribution graphed in Graph 6-H2-1. Graph 6-H2-2 repartitions the data from Graph 6-H2-1 into two categories. The "Yes" category implies that a respondent answered 1 to 5 on Question 24, and "No"

implies that a respondent answered 6 to 10 on Question 24. An Inference on a Single Proportion Test was conducted on the following hypothesis:

Null:	$p = 0.5$
Alternative:	$p > 0.5$
	Where p is the proportion of respondents that replied 6 to 10 on Question 24.

This test has a Z-score of -0.50, with a p-value of 0.310. Thus, fail to reject the null hypothesis. As such, the majority of end-users are not dissatisfied with the present level of software documentation.

This conclusion is in direct opposition to prior research that has shown that there is a widespread dissatisfaction among end-users with the quality of existing manuals and documentation. [ALLW97]

2.1.3 Hypothesis 3

End-users, in general, will claim that end-user documentation for major products is inadequate for their needs.

Statistics Used:	Inference on a Single Proportion Test
Survey Questions Used:	Question 37, limited to those who answered 7 on Question 31.
Tables and Diagrams:	Table 6-H3-1, Graphs 6-H3-1 and 6-H3-2

Question 37 of the survey inquired from the respondents how they would rate the documentation that is provided by the software manufacturer. Table 6-H3-1 depicts the responses from those individuals not involved with the software industry, with the distribution graphed in Graph 6-H3-1. Graph 6-H3-2 repartitions the data from Graph 6-H3-1 into two categories. The "Useless" category implies that a respondent answered 1 to 5 on Question 37, and "Helpful" implies that a respondent answered 6 to 10 on Question 37. An Inference on a Single Proportion Test was conducted on the following hypothesis:

Null:	$p = 0.5$
Alternative:	$p > 0.5$
	Where p is the proportion of respondents that replied 1 to 5 on Question 37.

This test has a Z-score of 0.20, with a p-value of 0.421. Thus, fail to reject the null hypothesis. As such, the majority of end-users do not consider current documentation methods unsatisfactory.

This conclusion is in direct opposition to prior research that has shown that there is a widespread dissatisfaction among end-users with the quality of existing manuals and documentation. [ALLW97]

2.2 Perceptions of the End-User on End-User Documentation

2.2.1 Hypothesis 4

End-users perceive that documentation management is inadequate.

Statistics Used:	Estimate of population proportion
Survey Questions Used:	Question 41
Tables and Diagrams:	Table 6-H4-1

Question 41 inquired about the confidence level of the respondent concerning the possession of the most recent edition of the User Documentation for all of the software products, either in-house or purchased off of the shelf that the respondent utilizes on a regular basis. Responses of 1 to 5 implied a certain level of confidence, whereas responses of 6 to 10 implied that the respondent was unconfident. From Table 6-H4-1 we can see that 411 of the 805 respondents, or 51.1%, claim a certain level of confidence in their possession of the most recent edition of the user documentation for the software they utilize. Constructing a 99.7% level of confidence for the estimate of the population proportion yields an interval of (0.4577, 0.5634), which yields inconclusive results for this hypothesis.

2.2.2 Hypothesis 5

End-users believe that software manufacturers treat end-user documentation as an after thought.

Statistics Used:	Estimate for Population Proportions
Survey Questions Used:	Questions 31 and 33.
Tables and Diagrams:	Table 6-H5-1, Graph 6-H5-1, and Graph 6-H5-2

Question 31 inquired of the respondents their involvement in the computer industry. 406 of the 805 respondents had absolutely no involvement in the computer industry as outlined in Table 6-H5-1. Question 33 inquired of all respondents how they would rate the software industry on the overall design and implementation of end-user documentation. Table 6-H5-2 depicts the distribution of the responses of the individuals who are not connected with the computer industry in tabular form. Restructuring the responses into two categories, with an answer of 5 or less implying that the individual perceives that the development of software product documentation is an afterthought, and responses of 6 or greater are perceived as the respondent does not think that the development of software product documentation is an afterthought of the developer, we get that 62.1% of the respondents felt that documentation could be, or is, an afterthought of the software developers. Constructing the estimate for population proportions with a 99.7% confidence level for the proportion of the respondents who felt that documentation could be, or is, an afterthought of the software developers, we get an interval of (0.5491, 0.6929). As such, it can be concluded that the majority of individuals who have absolutely no involvement with the software industry consider software product documentation an afterthought of the development process.

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2.2.3 Hypothesis 6

The majority of individuals will believe that software manufactures purposely develop bad end-user documentation.

Statistics Used:	Estimate for Population Proportions
Survey Questions Used:	Question 44

Tables and Diagrams: Table 6-H6-1

The survey question inquired the opinion of the respondents on whether or not they felt that software manufacturers purposely provide inferior documentation so that they could create an after-market. Table 6-H6-1 shows that only 33.8% of the respondents signified that they believe that software developers do not purposely develop bad end-user documentation. Construction of a 99.7% confidence level for the estimate of the population proportion who believe that software developers do not purposely develop bad end-user documentation yields an interval of (0.2880, 0.3880). Hence, it is reasonable to conclude that the majority of respondents do, or reasonably could, believe that software manufactures purposely develop bad end-user documentation.

2.2.4 Hypothesis 7

The majority of individuals will believe that vendor-supplied end-user documentation does not help them significantly.

Statistics Used: Estimate for Population Proportions
Survey Questions Used: Question 8
Tables and Diagrams: Table 6-H7-1

Table 6-H7-1 depicts the distribution of responses to Question 8, which inquired of the respondents what their beliefs were on the effect that software User Documentation has on their ability to properly utilize a computer. Partitioning the responses in Table 6-H7-1 into two groups, where a response of 6 or above implies that documentation has an impact, we see that 386 of the 805 respondents, or 47.95% claimed that documentation has an impact on their ability to utilize a computer system. Constructing a 99.7% confidence level of the proportion of the population yields an interval of (0.4267, 0.5323), thus yielding inconclusive results.

2.2.5 Hypothesis 8

Removal of printed end-user's manuals from the documentation suite will have the least effect on the end-user productivity, as perceived by the end-user.

Statistics Used: Chi-square

Survey Questions Used: Question 32

Tables and Diagrams: Table 6-H8-1

Table 6-H8-1 depicts the distribution of the responses to Question 32, which asked which documentation suite, if removed, would have the greatest impact on hindering the end-user's productivity. A Chi-square analysis of this data yields a resulting value of 0.00033, which implies that all answers to the question are of approximately equal value, and as such, no response in it own right would have a significant impact.

2.2.6 Hypothesis 9

The majority of individuals will believe that vendors purposely create an after market of additional books and materials for software products.

Statistics Used: Estimate for Population Proportions

Survey Questions Used: Question 44

Tables and Diagrams: Table 6-H9-1

The survey question inquired the opinion of the respondents on whether or not they felt that software manufacturers purposely provide inferior documentation so that they could create an after-market. Table 6-H6-1 shows that only 33.8% of the respondents signified that they believe that software developers do not purposely develop bad end-user documentation. Construction of a 99.7% confidence level for the estimate of the population proportion who believe that software developers do not purposely develop bad end-user documentation yields an interval of (0.2880, 0.3880). Hence, it is reasonable to conclude that the majority of respondents do, or reasonably could, believe that software manufactures purposely develop bad end-user documentation.

2.3 Are Current Documentation Methods Causing Maintenance Problems?

2.3.1 Hypothesis 10

An end-user's ability to utilize a computer system is hampered by current end-user documentation methods, techniques, and schemes.

Statistics Used: Estimate for Population Proportions

Survey Questions Used: Question 9

Tables and Diagrams: Table 6-H10-1

Question 9 inquires of the respondents if user documentation were to be improved, would this have an impact on your ability to utilize a computer. 7.43% of the respondents claimed that improved documentation would have no effect on their abilities. Constructing an estimate of population proportion for the proportion of the population who would claim that improved documentation would have no effect on their abilities yields an interval of (0.0597, 0.0889). Hence, it can be concluded that a vast majority of the population would experience an improvement in their abilities if documentation were to be improved.

2.3.2 Hypothesis 11

The majority of individuals will believe that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation.

Statistics Used: Inference on a Single Proportion Test

Survey Questions Used: Question 19

Tables and Diagrams: Table 6-H11-1

The survey question inquired from the respondents if they felt there was a "bug" in the software if they followed the instructions in the end-user documentation and did not achieve the desired results. An Inference on a Single Proportion Test was conducted on the following hypothesis:

Null: $p = 0.5$

Alternative: $p > 0.5$

Where p is the proportion of respondents that replied "No"

The results show that this test has a p-value of 0.000. Therefore, at the 5% level of significance, reject the null hypothesis, and therefore, the majority of individuals do not feel that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation.

2.3.3 Hypothesis 12

Given that the hypothesis of "The majority of individuals will believe that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation (Hypothesis 11)" is confirmed, end-users will then report the "bug" to a "Help Desk."

Statistics Used: None
Survey Questions Used: Question 20
Tables and Diagrams: None

Since the Hypothesis 11 was not confirmed, no statistical analysis will be conducted.

2.4 Current Problems with End-user Documentation

2.4.1 Hypothesis 13

Current end-user documentation has too many steps to easily remember.

Statistics Used: Inference on a Single Proportion Test
Survey Questions Used: Question 43
Tables and Diagrams: Table 6-H13-1

The survey question inquired of the respondents their opinion on whether or not software product documentation generally has too many steps to easily remember how to accomplish a given task without looking back at the documentation. An Inference on a Single Proportion Test was conducted on the following hypothesis:

Null: $p = 0.5$
Alternative: $p > 0.5$

Where p is the proportion of respondents that

replied "No"

The results show that this test has a Z-score of -1.23, with a p-value of 0.109. Therefore, at the 5% level of significance, we reject the null hypothesis, and therefore, the majority of individuals do not feel that current software documentation methods have too many steps to easily remember.

This conclusion appears to be in direct conflict with research that has shown that a major problem with many conventional manuals seems to be that they focus more on the system than on the users and their tasks. This research continued to state that user manuals could be said to be designed in conflict with the users' primary goal, which is to carry out their work tasks rather than to read about how to do so. [CARR88]

2.4.2 Hypothesis 14

Although the primary function of a respondent's job is dealing with a computer system, they will generally feel unconfident about their skills.

Statistics Used:	Estimate for Population Proportions
Survey Questions Used:	Question 7, limited to those who answered "Yes" to question 13.
Tables and Diagrams:	Table 6-H14-1

581 of the 805 respondents to the survey had the use of a computer system and software packages as a primary function of their work. As can be viewed from the table, 62.1% of the respondents whose primary function of their work is use of a computer and software packages feel some level of comfortable using a computer. Constructing a 99.7% confidence level for the estimate for the population proportion of all individuals whose work requires the use of a computer and software package, and who feel comfortable using the computer, yields an interval of (0.5606, 06813). Thus it must be concluded to reject the hypothesis of although the primary function of a respondent's job is dealing with a computer system they will generally feel unconfident about their skills.

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2.4.3 Hypothesis 15

End-users fear a new release of software because of the learning curve.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Question 42
Tables and Diagrams:	Table 6-H15-1

The survey question inquired from the respondents their fear of having to re-learn a product upon product upgrade or maintenance release. A 95% confidence interval of (0.516440, 0.586287) was calculated for the proportion of individuals that would not fear a new release of software. Based on this confidence interval, it is therefore concluded that the hypothesis should be rejected, and that the majority of individuals do not fear a new release of software because of the learning curve.

2.5 Education and Training Issues Surrounding End-User Documentation

2.5.1 Hypothesis 16

End-users will say that they find instructor-lead classes to be more effective than current documentation methods.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Question 34
Tables and Diagrams:	Table 6-H16-1

The survey question inquired of the respondents which method would be more helpful than the current method of printed documentation. A 95% confidence interval of (0.105650, 0.153015) for the proportion of individuals that would find instructor-lead classes to be more effective than current documentation methods was computed. Based on this confidence interval, it is therefore concluded that the vast majority of individuals would not find instructor-lead classes to be more effective than current documentation methods.

This conclusion appears to be in agreement with research that has shown that end-users are impatient learners and want to get started quickly on something productive

[RETT91], instruction, regardless of form, should not be tailored to one particular method of learning or learning ability for constant distribution [AGAR96], and that Lecturing is the *least* effective instructional method. [MEYE99]

2.5.2 Hypothesis 17

The vast majority of the user community will admit that they utilize the resources of a friend or an associated before they attempt to utilize a software package's user documentation.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Question 36
Tables and Diagrams:	Table 6-H17-1

The survey question inquired from the respondents if they were likely to call a friend, or use some other form of solving a problem, when they encountered a problem with a software package. A 95% confidence interval of (0.188176, 0.246218) for the proportion of individuals that would use a friend was constructed. Based on this confidence interval, it is therefore concluded that the vast majority of individuals will not use a friend or an associated before they attempt to utilize a software package's user documentation.

This conclusion appears to be in direct conflict with prior research that showed that end-users would most likely consult another person, either a co-worker or a friend, on how to perform the desired task, rather than the documentation. [RETT91, DENT93, CHAR91, CRIC83, CROW92, GEMO90, COST99]

2.5.3 Hypothesis 18

Printed documentation would be the least missed, of all of the user-documentation methods, if omitted from a software product.

Statistics Used:	Chi-Square
Survey Questions Used:	Question 32
Tables and Diagrams:	Tables 6-H18-1, 6-H18-2 and 6-H18-3

The survey question inquired from the respondents if a software product documentation suite contains Icons, On-line Help, Menus, printed User's Manuals, and Wizards, which of the preceding, if removed from the product, would not hinder your productivity with the product. A Chi-Square analysis was conducted, and it shows that there is a dependency, at the 5% level of significance, upon the removal of a documentation product.

Inspection of Table 6-H18-2 shows that the On-line Help, with 14.8% of the respondents signifying that removal of this product would hinder their productivity, appears to be the product that would be least missed. As such, the hypothesis is rejected.

2.5.4 Hypothesis 19

As a group, individuals over the age of 50 will find computers, and associated documentation, harder to deal with and comprehend.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Questions 7 and 30, limited to those who responded 10 to 18 on Question 3
Tables and Diagrams:	Tables 6-H19-1, 6-H19-2, 6-H19-3, 6-H19-4, and Graphs 6-H19-1 and 6-H19-2

First, Question 7 inquired of the respondents their comfort level on using a computer. A 95% confidence interval of (0.533309, 0.684082) was computed for the proportion of the respondents over the age of 50 who felt comfortable using a computer system. As such, the hypothesis that this group will find computers hard to deal with is rejected.

Secondly, Question 30 of the survey inquired of the respondents how easy they found computer documentation to read and comprehend. A 95% confidence interval on the proportion of respondents over the age of 50 that find documentation difficult to read

is (0.520485, 0.6720610). As such, the hypothesis that older individuals will find documentation hard to read is not rejected.

This "split decision," where older individuals are comfortable on computers but find documentation difficult, on this hypothesis appears to both confirm and contradict the research that has shown that older people are faced with the expectations of their colleagues, friends, and family, on a daily basis, about what they can and cannot do – and eventually begin to underestimate themselves and their abilities. [HESS94, COLE93]

2.5.5 Hypothesis 20

As a group, the individuals between the ages of 10 and 35 will find the computer easier to deal with, and understand the associated documentation.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Questions 7 and 30, limited to those who responded 1 to 6 on Question 3
Tables and Diagrams:	Tables 6-H20-1, 6-H20-2, 6-H20-3, 6-H20-4, and Graphs 6-H20-1 and 6-H20-2

First, Question 7 inquired of the respondents their comfort level on using a computer. A 95% confidence interval of (0.612642, 0.703273) was computed for the proportion of the respondents between the ages of 10 and 35 who felt comfortable using a computer system. As such, the hypothesis that this group will find computers hard to deal with is rejected.

Secondly, Question 30 of the survey inquired of the respondents how easy they found computer documentation to read and comprehend. A 95% confidence interval on the proportion of respondents between the ages of 10 and 35 that find documentation difficult to read is (0.0571155, 0.663999). As such, the hypothesis that younger individuals will find documentation easier to read is rejected.

This "split decision," where younger individuals are comfortable on computers but find documentation difficult, on this hypothesis appears to support the concept of the visual impact of the interface to the end-user is of vital importance. Research on the matter has shown that the end-user interface must be intuitive so that required documentation on the operation of the software product is either unnecessary or minimized. [AGAR96] Individuals within this age group, empirically speaking, have been exposed, some would say heavily, to gaming software, icons, and wizards. As such, it is assumed that this group gravitates towards the visual documentation, icons and similar devices, over the printer paper product. Additionally, the general overall reading level of this age group must be taken into consideration.

2.5.6 Hypothesis 21

Common-day software applications, such as Automated Teller Machines, which are supposed to be self-documenting systems, will on the most part, be more difficult to use by older individuals, where older is age greater than or equal to 50.

Statistics Used:	Inference on Two Proportions Test
Survey Questions Used:	Question 10
Tables and Diagrams:	Table 6-H21-1 summarizes the overall responses to this question, and Table 6-H21-2 summarizes the responses according to age

The survey question inquired from the respondents if they had any difficulty using an Automated Teller Machine. Examining the table in the appendix shows that only 15 of the 161 individuals over the age of 50 had, or infrequently had, trouble with an Automated Teller Machine, compared to the 41 of the 644 individuals aged 50 or below.

To confirm the hypothesis that common-day software applications, such as Automated Teller Machines, which are supposed to be self-documenting systems, will on the most part, be more difficult to use by older individuals, where older is age greater than or equal to 50, a test was performed with the following hypothesis:

Null:	Proportion "Young" Answering "Yes" = Proportion "Old" Answering "Yes"
Alternative:	Proportion "Old" Answering "Yes" > Proportion "Young" Answering "Yes"
Where:	"Yes" is either a "Yes" or "Sometimes" answer to Question 10, and "Old" is being over the age of 50, and "Young" is being under the age of 50.

Results:

Sample Proportion for "Old" (p("Old")):	0.093168
Sample Proportion for "Young" (p("Young")):	0.063665
Estimate for p("Old") – p("Young"):	0.0295031
Test statistic for p("Old") – p("Young") = 0 yields a Z-score statistic of	1.19
Such a Z-score has a p-value of	0.235

At the 5% level of significance it is concluded to reject the hypothesis that common-day software applications, such as Automated Teller Machines, which are supposed to be self-documenting systems, will on the most part, be more difficult to use by older individuals, where older is age greater than or equal to 50.

This conclusion appears to be in conflict with the research that claimed that older people are faced with the expectations of their colleagues, friends, and family, on a daily basis, about what they can and cannot do – and eventually begin to underestimate themselves and their abilities. [HESS94, COLE93]

2.5.6 Hypothesis 22

American idiomatic phrases have a significant impact on end-users ability to understand and utilize end-user documentation.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Question 27
Tables and Diagrams:	Tables 6-H22-1, 6-H22-2, and 6-H22-3

The survey question inquired from the respondents their belief on the subject of the affect of American idiomatic phrases in software product documentation. As can be seen from the table, 90.1% of all respondents felt that American idiomatic phrases hindered non-native American English speaking individuals.

Table 6-H22-2 summarizes the responses based upon the native language of the respondent. Removing the 543 native American English-speaking respondents produces Table 6-H22-3. As can be seen from the table, only 39 non-native American English respondents, or 14.89%, felt that American idiomatic phrases did not have an impact. A 95% confidence interval of (0.108041, 0.197825) was constructed. Based on this confidence interval, it is therefore concluded that very few non-native American English speakers would find that American idiomatic phrases were non-problematic.

This conclusion is in direct support to the following research:

- An individual's ability to learn, and perform, a task is directly related to how similar they feel to the method of presentation or to the task itself. [MOON98]
- A user manual is of very little value if the users cannot understand or follow its instructions. [ALLW97]
- User manuals may not provide information in a form that the user can easily utilize [ALLW86, DRAP92, LEWI82] and this is a problem for novice users. [ALLW90]

2.5.7 Hypothesis 23

As a group, women will find documentation harder to understand and utilize than men will. (Corollary: Gender specific terminology will have an impact.)

Statistics Used:	Chi-Square and Inference on Two Proportions Test
Survey Questions Used:	Questions 17 and 40

Tables and Diagrams: Tables 6-H23-1, 3-H23-2, 3-H23-3, 6-H23-4, and 6-H23-5

To confirm, or reject, the above hypothesis a Chi-Square test will be performed first to confirm that the perceived understandability and comprehensibility of software documentation is independent of sex. With a p-value from this test of approximately 0.001, and remembering that the Chi-square tests the null hypothesis that the row variable and the column variable are independent of each other, it is concluded that the perceived understandability and comprehensibility of software documentation is dependent on the sex of the respondent.

To test the hypothesis that women find documentation harder to understand and comprehend than men, the responses from the survey question will be summarized into two categories. If the respondent provided either a "Yes" or "Sometimes" response, this will be considered a "Positive" response. If the respondent provided either a "Not Often" or "No" response, this will be considered a negative response for the purposes of this analysis. After performing this summarization, we receive Table 3-H23-3.

To confirm the hypothesis that women, as a group, find documentation more difficult to understand and comprehend than men, an Inference on Two Proportions Test will be performed with the following hypothesis:

Null:	Proportion Men answering No = Proportion Women answering No
Alternative:	Proportion Women answering No > Proportion Men answering No

Results:

Sample Proportion for males (p(male)):	0.232432
Sample Proportion for females (p(female)):	0.292000
Estimate for p(females) – p(males):	0.0595676
Test statistic for p(female) – p(male) = 0 yields a Z-score statistic of	1.76

Such a Z-score has a p-value of 0.079

At the 5% level of significance, reject the hypothesis that women, as a group, will find documentation harder to understand and utilize than men will. (Corollary: Gender specific terminology does not have an impact on software documentation.)

Two special items must be brought to attention at this point in time. First, if the Chi Square test is performed on Table 6-H23-3 a different result for independence is found. Specifically, the Chi-Square value for Table 6-H23-3 is 3.254. With 1 degree of freedom, the p-Value for this test becomes 0.071. Hence, at the 5% level of significance we would fail to reject the null hypothesis of there is no relationship between row and column frequencies.

Secondly, the results to Question 40, summarized in Table 6-H23-4, show that, as a general rule, the overwhelming majority of men and women do not consider gender specific terminology as a hindrance. Further analysis, as depicted in Table 6-H23-5, shows that, contrary to popular belief; younger men and women were the individuals that marked the affirmative answers ("Yes" and "Sometimes") to Question 40.

Additionally, the conclusion of this hypothesis is in direct contradiction to early research [ARCH96] that showed that gender labeling of tasks has an effect on the learning ability of the individual.

2.5.8 Hypothesis 24

End-users will signify that Goal/Objective oriented end-user documentation will increase their satisfaction with software products.

Statistics Used:	Estimate of Population Proportion
Survey Questions Used:	Questions 22 and 28
Tables and Diagrams:	Tables 6-H24-1, 6-H24-2, and 6-H24-3

The survey question inquired of the respondents if goal/objective oriented documentation would have an impact on their productivity and satisfaction. To test

the hypothesis above, Table 6-H24-2 was constructed. In the construction of this table, all responses that were 6 or greater were considered to be a "Yes" response. A 95% confidence interval of (0.632071, 0.698386) was constructed. Based on this confidence interval, it is therefore concluded that the majority of end-users would signify that goal / objective oriented documentation would increase their productivity and satisfaction with software products.

This conclusion is in direct support of other research conducted by Carroll et al. [CARR88a] Further support of this conclusion is offered by the responses to Question 28 of the survey. Question 28 inquired if "recipe-type" documentation would improve productivity. Table 6-H24-3 summarizes the responses. As can be seen, 88.3% of the respondents felt that "recipe-type" documentation would or could improve their productivity.

2.5.9 Hypothesis 25

The average person will state that the documentation supplied with game-oriented software is easier to comprehend and utilize than that of "standard" application packages, or will not need to use it at all.

Statistics Used:	Estimate of Population Proportion.
Survey Questions Used:	Question 15.
Tables and Diagrams:	Table 6-H25-1.

The survey question inquired of the respondents their perceptions of the documentation supplied with computer games. As can be summarized from the table, 554 respondents found that the documentation with computer games to be not as difficult, or easier, than other software product documentation.

A 95% confidence interval of (0.654931, 0.720081) was constructed. Based on this confidence interval, it is therefore concluded that the majority of end-users would signify that documentation supplied with computer games is not as difficult or easier to use and comprehend. This conclusion is in direct support of the following research:

- Novices to a subject area require a feedback loop that informs them of errors and intentions, with intentions being viewed as what is the next step in the process. [HAAK99]
- Motivation and incentives play a large roll in the speed at which an individual learns, in particular a software product [AGAR96]
- The type of user interface used with a software product will induce a learning mode of either explicit or implicit. Individuals learning in an explicit mode must have a conscious and selective attention towards a given subject, whereas learning through an implicit mode implies a trial and error approach. Direct manipulation devices, such as a computer mouse, are commonly associated with the implicit method of learning. Experiments have shown that the traditional definition of "user friendliness" does not automatically correspond to the best performance in terms of efficient learning. It has been suggested that user-friendliness be re-defined to focus on the quality of learning the product. [SCHA96]
- People, in general, can recall material better, or in other words learn more easily, if more than one of the senses is stimulated during the process of learning. [TRUM98]
- The more an individual feels in control of the situation the more quickly that individual will master the subject. [MOON98]
- Interactions with computers and information about computer processing are significant factors that affect user anxiety. [GALA83]
- Learners can remember and process more information from a visual stimulus than from a written document. [MILL82]
- According to Carroll et al [CARR88a] minimalist approach manuals which are short in length, task-oriented, and support error recognition and recovery, will help novice users to lean how to operate a computer in less time and with better skills

than a conventional manual. Although the minimalist approach appears to be an effective method to user manual design that outperforms most traditionally produced manuals, some of its empirical claims have nevertheless been criticized and challenged by several authors. (Brockman [BROC90], Charney et al [CHAR88, CHAR90], Draper and Oatley [DRAP92], Nickerson [NICK91], Tripp [TRIP90], Williams and Farkas [WILL92])

3. Summary

The results of the above analysis of the hypotheses are summarized below:

Hypothesis	Accept	Reject
Hypothesis 1: Individuals employed within the computer industry will claim that current software practices concerning end-user documentation are adequate for the end-user, and that end-user documentation is well developed.		X
Hypothesis 2: End-users as a group will signify that their over-all satisfaction level with end-user documentation is very low.		X
Hypothesis 3: End-users, in general, will claim that end-user documentation for major products is inadequate for their needs.		X
Hypothesis 4: End-users perceive that documentation management is inadequate.	?	?
Hypothesis 5: End-users believe that software manufacturers treat end-user documentation as an after thought.	X	
Hypothesis 6: The majority of individuals will believe that software manufactures purposely	X	

develop bad end-user documentation.		
Hypothesis 7: The majority of individuals will believe that vendor-supplied end-user documentation does not help them significantly.	?	?
Hypothesis 8: Removal of printed end-user's manuals from the documentation suite will have the least effect on the end-user productivity, as perceived by the end-user.		X
Hypothesis 9: The majority of individuals will believe that vendors purposely create an after market of additional books and materials for software products.	X	
Hypothesis 10: An end-user's ability to utilize a computer system is hampered by current end-user documentation methods, techniques, and schemes.	X	
Hypothesis 11: The majority of individuals will believe that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation.		X
Hypothesis 12: Given that the hypothesis of "The majority of individuals will believe that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation (Hypothesis 11)" is confirmed, end-users will then report the "bug" to a "Help Desk."	?	?
Hypothesis 13: Current end-user documentation has too many steps to easily remember.		X

Hypothesis 14: Although the primary function of a respondent's job is dealing with a computer system, they will generally feel unconfident about their skills.		X
Hypothesis 15: End-users fear a new release of software because of the learning curve.		X
Hypothesis 16: End-users will say that they find instructor-lead classes to be more effective than current documentation methods.		X
Hypothesis 17: The vast majority of the user community will admit that they utilize the resources of a friend or an associated before they attempt to utilize a software package's user documentation.		X
Hypothesis 18: Printed documentation would be the least missed, of all of the user-documentation methods, if omitted from a software product.		X
Hypothesis 19: As a group, individuals over the age of 50 will find computers, and associated documentation, harder to deal with and comprehend.	½	½
Hypothesis 20: As a group, the individuals between the ages of 10 and 35 will find the computer easier to deal with, and understand the associated documentation.	½	½
Hypothesis 21: Common-day software applications, such as Automated Teller Machines, which are supposed to be self-documenting systems, will on the most part, be more difficult to		X

use by older individuals, where older is age greater than or equal to 50.		
Hypothesis 22: American idiomatic phrases have a significant impact on end-users ability to understand and utilize end-user documentation.	X	
Hypothesis 23: As a group, women will find documentation harder to understand and utilize than men will. (Corollary: Gender specific terminology will have an impact.)		X
Hypothesis 24: End-users will signify that Goal/Objective oriented end-user documentation will increase their satisfaction with software products.	X	
Hypothesis 25: The average person will state that the documentation supplied with game-oriented software is easier to comprehend and utilize than that of "standard" application packages, or will not need to use it at all.	X	

4. Conclusions

A recapitulation of the conclusions made after the statistical analysis of each of the hypotheses shows that:

1. The majority of software developers and maintainers consider software product documentation an afterthought of the development process. (Obtained from Hypothesis 1, Survey Questions 31 and 33)
2. The majority of end-users are not dissatisfied with the present level of software documentation. (Hypothesis 2, Survey Questions 24 and 31)
    a. This conclusion is in direct opposition to prior research that has shown that there is a widespread dissatisfaction among end-users with the quality of existing manuals and documentation.

3. The majority of end-users do not consider current documentation methods unsatisfactory. (Obtained from Hypothesis 3, Survey Questions 31 and 37)
    a. This conclusion is in direct opposition to prior research that has shown that there is a widespread dissatisfaction among end-users with the quality of existing manuals and documentation.
4. Statistically inconclusive results on the perception of the end-user on end-user documentation management. (Obtained from Hypothesis 4, Survey Question 41)
5. The majority of individuals who have absolutely no involvement with the software industry consider software product documentation an afterthought of the development process. (Obtained from Hypothesis 5, Survey Questions 31 and 33)
6. The majority of survey respondents do, or reasonably could, believe that software manufactures purposely develop bad end-user documentation. (Obtained from Hypothesis 6, Survey Question 44)
7. Statistically inconclusive results on how the end-user belief how helpful vendor-supplied end-user documentation is. (Obtained from Hypothesis 7, Survey Question 8)
8. End-users feel that removal of any of the existing end-user documentation methods, as outlined in the survey, would have an approximately equal impact. (Obtained from Hypothesis 8, Survey Question 32)
9. The majority of survey respondents do, or reasonably could, believe that software manufactures purposely develop bad end-user documentation. (Obtained from Hypothesis 9, Survey Question 44)
10. A vast majority of the population surveyed would experience an improvement in their abilities if documentation were to be improved. (Obtained from Hypothesis 10, Survey Question 9)
11. The majority of individuals who responded to the survey do not feel that there is a "bug" in the software if the desired output is not obtained when they follow the instructions that are given in the end-user documentation. (Obtained from Hypothesis 11, Survey Question 19)

12. The majority of respondents to the survey do not feel that current software documentation methods have too many steps to easily remember. (Obtained from Hypothesis 13, Survey Question 43)
    a. This conclusion appears to be in direct conflict with research that has shown that a major problem with many conventional manuals seems to be that they focus more on the system than on the users and their tasks. This research continued to state that user manuals could be said to be designed in conflict with the users' primary goal, which is to carry out their work tasks rather than to read about how to do so.
13. Survey respondents whose primary work function required dealing with a computer system and software packages generally felt confident about their skills. (Obtained from Hypothesis 14, Survey Questions 7 and 13)
14. The majority of individuals responding to the survey do not fear a new release of software because of the learning curve. (Obtained from Hypothesis 15, Survey Question 42)
15. The vast majority of individuals responding to the survey would not find instructor-lead classes to be more effective than current documentation methods. (Obtained from Hypothesis 16, Survey Question 34)
    a. This conclusion appears to be in agreement with research that has shown that end-users are impatient learners and want to get started quickly on something productive, instruction, regardless of form, should not be tailored to one particular method of learning or learning ability for constant distribution, and that lecturing is the least effective instructional method.
16. The vast majority of individuals responding to the survey will not use a friend or an associated before they attempt to utilize a software package's user documentation. (Obtained from Hypothesis 17, Survey Question 36)
    a. This conclusion appears to be in direct conflict with prior research that showed that end-users would most likely consult another person, either a co-worker or a friend, on how to perform the desired task, rather than the documentation.

17. Removal of the on-line help feature of software products would hinder the end-user the least. (Obtained from Hypothesis 18, Survey Question 32)
18. Older individuals are comfortable on computers but find documentation difficult. (Obtained from Hypothesis 19, Survey Questions 3, 7, and 30)
19. Younger individuals are comfortable on computers but find documentation difficult. (Obtained from Hypothesis 20, Survey Questions 3, 7, 30)
20. Automated teller machines are easy to use by all age groups. (Obtained from Hypothesis 21, Survey Question 10)
21. Very few non-native American English speakers would find that American idiomatic phrases were non-problematic. In other words, the use of American idiomatic phrases causes problems for non-native American English speaking individuals. (Obtained from Hypothesis 22, Survey Question 27)
22. Gender does not play a role in the understandability of end-user documentation. (Obtained from Hypothesis 23, Survey Questions 17 and 40)
    a. This conclusion is in direct contradiction to early research, discussed in Chapter 2, which showed that gender labeling of tasks has an effect on the learning ability of the individual.
23. The majority of end-users would signify that goal / objective oriented documentation would increase their productivity and satisfaction with software products. (Obtained from Hypothesis 24, Survey Questions 22 and 28)
    a. This conclusion is in direct support of other research conducted by Carroll et al, as discussed in Chapter 2. Further support of this conclusion is offered by the responses to Question 28 of the survey. Question 28 inquired if "recipe-type" documentation would improve productivity. Table 6-H24-3 summarizes the responses. As can be seen, 88.3% of the respondents felt that "recipe-type" documentation would or could improve their productivity.

24. The majority of end-users would signify that documentation supplied with computer games is not as difficult or easier to use and comprehend. (Obtained from Hypothesis 25, Survey Question 15)

    a. This conclusion is in direct support of the following research, as outlined in Chapter 2 of this thesis:

        i. Novices to a subject area require a feedback loop that informs them of errors and intentions, with intentions being viewed as what is the next step in the process.

        ii. Motivation and incentives play a large roll in the speed at which an individual learns, in particular a software product.

        iii. The type of user interface used with a software product will induce a learning mode of either explicit or implicit. Individuals learning in an explicit mode must have a conscious and selective attention towards a given subject, whereas learning through an implicit mode implies a trial and error approach. Direct manipulation devices, such as a computer mouse, are commonly associated with the implicit method of learning. Experiments have shown that the traditional definition of "user friendliness" does not automatically correspond to the best performance in terms of efficient learning. It has been suggested that user-friendliness be re-defined to focus on the quality of learning the product.

        iv. People, in general, can recall material better, or in other words learn more easily, if more than one of the senses is stimulated during the process of learning.

        v. The more an individual feels in control of the situation the more quickly that individual will master the subject.

        vi. Interactions with computers and information about computer processing are significant factors that affect user anxiety.

        vii. Learners can remember and process more information from a visual stimulus than from a written document.

viii. According to Carroll et al, minimalist approach manuals which are short in length, task-oriented, and support error recognition and recovery, will help novice users to lean how to operate a computer in less time and with better skills than a conventional manual. Although the minimalist approach appears to be an effective method to user manual design that outperforms most traditionally produced manuals, some of its empirical claims have nevertheless been criticized and challenged by several authors.

In reference to the concept of the IDP, the interactive goal-oriented documentation store as outlined in Chapter 4, the following analysis on the success of this concept can be made:

1. Although the majority of end-users are not dissatisfied with the present level of software documentation, and they do not consider current documentation methods unsatisfactory, they do claim that the introduction of goal / objective oriented documentation would increase their productivity and satisfaction with software products. As such, the IDP meets the desires of the end-user for goal / task oriented software documentation. (Conclusion drawn from Hypotheses 2, 10, and 24)

2. Individuals of all age ranges find end-user documentation difficult in its present form. As such, this signifies that the software development community should respond to the needs of the end-user by developing a better end-user documentation paradigm. (Conclusion drawn from Hypothesis 19 and 20)

3. Self-documenting, goal-oriented, intuitive products, such as automated teller machines, are easy to use and understand by all individuals, regardless of sex, educational achievement, or age. All documentation products of the IDP, by the definitions supplied in Chapter 4, are goal-oriented. (Conclusion drawn from Hypotheses 21 and 24)

4. All individuals, regardless of their connection with the software development industry, consider end-user documentation an afterthought of the development process. The IDP, as discussed in Chapter 4, is a pro-active component of the software product, and as such, would no longer be an after-thought of the development process. (Conclusion drawn from Hypotheses 5 and 16)

5. Although the vast majority of individuals responding to the survey will not use a friend or an associated before they attempt to utilize a software package's user documentation, this does not preclude the use of the IDP. Although the IDP is based upon the concept of being the "friend of choice," it is also based upon the concept of goal and task-oriented documentation. The results of this survey show that the end-user desires such a documentation product, and as such, it is felt that the end-user would gravitate towards the use of the IDP. (Conclusion drawn from Hypothesis 17)

6. Although survey respondents felt that current documentation methods do not contain too many steps, research in the disciplines of education and psychology have shown that there is a limit to the number of steps that an individual can remember. The IDP capitalizes upon the research in these other disciplines, and it is felt that when the IDP is implemented, end-users will be able to learn how to use the software product in a quicker fashion, and have a significantly improved retention level of these learned skills. (Conclusion drawn from Hypotheses 13 and 24)

7. Idiomatic phrases are problematic for some individuals. The IDP, being totally task oriented, would have a minimal, if any, amount of idiomatic phrases; thus removing this barrier for end-users successfully utilizing software products. (Conclusion drawn from Hypothesis 22)

As a by-product of the research conducted for this thesis, it is noted that end-users, although apparently satisfied with the present documentation paradigm, are confident that software developers purposely produce inferior products, and treat the end-user

documentation as an after-thought, in order to create an after-market of documentation products. This skepticism on the part of the end-user could have introduced a significant bias into the results of the survey, but it does indicate that the software development industry needs to re-evaluate its position on end-user documentation and to create a new end-user documentation paradigm.

Chapter 7

PROPOSED DOCUMENTATION PARADIGM

1. Introduction

As illustrated in Figure 1-1 of Chapter 1, the Modified Foster Model was born from the amalgamation of the research conducted by those within the software maintenance community and those in the educational and psychological communities. But, the question of what the documentation utilized within the Interactive Documentation Program (IDP) should look like, and how it should function, remained an open question.

Combining the results of the statistical analysis on the needs and desires of the end-user community, as conducted in Chapter 6, with the concept of the IDP in Chapter 4 results in the documentation paradigm discussed in this chapter.

2. How Should End-user Documentation Be?

In Chapter 2 of this thesis, it was shown that there is very little literature available on the subject of end-user documentation production. The analysis of the survey conducted during the course of this research in Chapter 6, in concert with the research conducted by other researchers as discussed in Chapter 2, demonstrates that the following items are of key importance in the development of effective end-user documentation:

- Hypotheses 13, 21, and 24 of this thesis, and research conducted by others as outlined in Chapter 2, show that End-users signify that Goal/Objective oriented end-user documentation will increase their satisfaction with software products. (In corollary, in order to be effective to the end-user,

and improve the end-user's learning and understanding of the software product, documentation should be task oriented, versus system oriented, and concise.)

- Learners can remember and process more information from a visual stimulus than from a written document. (In corollary, the visual impact of the interface to the end-user is of vital importance. In essence, the end-user interface must be intuitive so that required documentation on the operation of the software product is either unnecessary or minimized.)
- The results from Hypotheses 13, 21, and 24 confirm that minimalist approach manuals which are short in length, task-oriented, and support error recognition and recovery, will help novice users to learn how to operate a computer in less time and with better skills than a conventional manual.
- Hypothesis 21 confirms that novices to a subject area require a feedback loop that informs them of errors and intentions, with intentions being viewed as what is the next step in the process.
- Hypotheses 13, 21, and 24 confirm that people, in general, can recall material better, or in other words learn more easily, if more than one of the senses is stimulated during the process of learning.
- Hypothesis 14, and the research discussed in Chapter 2, confirms that the more an individual feels in control of the situation the more quickly that individual will master the subject.
- Hypothesis 3 confirms that end-users are discouraged, not empowered, by large manuals with each task decomposed into its subtask minutiae.
- Hypothesis 21 confirms that graphical interfaces, when considered as end-user documentation, have considerably improved human-computer interaction.

- Hypotheses 19 and 20 confirm that a user manual is of very little value if the users cannot understand or follow its instructions.
- Hypothesis 24 confirms that a major problem with many conventional manuals seems to be that they focus more on the system, than on the users and their tasks, and thus they can be said to be designed in conflict with the users' primary goals which is to carry out their work tasks rather than read about how to do so.

As discussed in Chapter 2, there are some major issues with the human learning process:

- *Learning, whether it is associated with a software product or not, has several variables that can affect an individual's ability to master a subject area.*
- *Instruction, regardless of form, should not be tailored to one particular method of learning or learning ability for constant distribution.*
- *Instruction should create a climate of collaboration between others.*
- *Ideally, training should be individualized to accommodate each individual's unique characteristics.*

Therefore, *it may be impossible* to develop an end-user documentation paradigm that will satisfy all end-users all of the time, but it may be possible to create a documentation paradigm that will satisfy most of the end-users most of the time.

3. The Design of the End-user Documentation Product

At the close of World War II, Dr. Vannevar Bush first described the concept, presently known as hypertext, of linking information in one document with that of another; forming a trail of knowledge specifically designed for, and by, the individual person. [BUSH45] Hypertext has been proposed as a tool for documenting the systems and software that allowed for its very existence. [BLUM88, FLET88] But these proposals

still use hypertext to inter-link textual documents and lines of software to the supporting documentation. These proposals are very good for the developers and maintainers of software, but not for the end-user. As shown in the demographics of the individuals surveyed in Chapter 5, the average end-user has below a collegiate education, but is required to interface with a computer in some manner or form on an almost daily basis, and as such, would presumably need to use some form of end-user documentation at various points in time. As discussed earlier in this chapter, the problem of creating a documentation paradigm that will meet most, or all, of the key elements mentioned in the above section may be an impossibility, but a proposed method that meets a significant portion of these requirements, called hypervideo, will be introduced after a short description of the current technology.

Enhancements to the World-Wide Web now allow for video snippets to be transmitted across the Internet. These video snippets can be accompanied by audio tracks if the developer so desires. To activate a current video snippet, the end-user clicks on a hypertext or hypergraphic link to download or activate the snippet. Each snippet is an independent object, with no links to other snippets.

Conversely, in hypervideo each object within a hypervideo frame will be a hyperlink to another hypervideo snippet. Each video snippet could be a full motion video, video still picture, or a graphic. For example, clicking on an object within one hypervideo snippet will transport the end-user to a hypervideo detailing the selected object's function. Text and audio tracks with spoken accompaniments will be kept to a minimum.

To illustrate hypervideo's flexibility on documenting the use of a software application, the example of an end-user operating an automated teller machine will be discussed. When an end-user approaches a hypervideo-equipped automated teller machine, the first thing that one would notice on the screen would be a video still-picture of a door. Touching the door, it would open, and a new video snippet would appear. On this snippet would be several graphical images: one showing a person putting money into an envelope for deposit; another showing money being put into a wallet after a withdrawal; and another door (for other transactions such as account transfers).

Touching the hypervideo depicting a withdrawal, the end-user would then see a hypervideo on how to perform the task. Regardless of the reading level, educational level, or language spoken by the end-user, the hypervideo would "walk" the user through all of the necessary functions to withdraw money from the automated teller machine. For other applications, such as Microsoft Word, similar hypervideos could be made, each depicting a specified task.

Hypervideo's advantages carry directly over to the World-Wide Web. Supposing that each Web page became a hypervideo page, international commerce across the Web would become a true reality. Hypervideos would demonstrate the functionality of items to be sold to the end-user, provide interactive tours of museums or cities, or provide instruction on software packages. Regardless of the native language of the end-user, simple hypervideos of various tasks to be performed would literally "walk" the user through the use of the application.

At this point, a comparison of hypervideo to the requirements specified in Section 3 becomes necessary. Cleary, hypervideo is task-oriented, visual stimulus-based method of delivering information, concepts, and instruction, and as such, based upon the results of the analysis in Chapter 6 and the research of the education and psychology communities discussed in Chapter 2, should enable end-users to easily remember how to perform a task. Furthermore, being goal oriented, as described above, it should increase the satisfaction of the end-user with the software product based upon the analysis of Hypotheses 13, 21, and 24 in Chapter 6.

Additionally, since there are no printed manuals involved with hypervideo, the problem of end-users being discouraged by voluminous materials, as revealed in Chapter 2 and Chapter 6, should be eliminated. Moreover, the end-user is in control of which hypervideo is played, how often it is played, and as such, should empower the end-user. As such, according to Hypothesis 14 in Chapter 6 and the research by the educational and psychological communities, the individual end-user should quickly master the material covered in the hypervideo.

The only apparent flaw with hypervideo, at this point in time, is that it does not directly provide a feed-back loop to the end-user, although it is stimulating at least two (tactile and visual), if not more, of the senses (auditory if sound is included with the snippet). Conceptually speaking, hypervideo appears to meet virtually of the desires of the end-users, as surveyed during the course of this research, and the requirements of improving the retention of information as outlined by the educational and psychological communities in Chapter 2.

This researcher did not attempt to implement hypervideo during the course of this research for two major reasons. Firstly, in order to implement hypervideo, research must be conducted on what would be the most effective universally understood video snippets for common actions. These snippets, similar to the International Traffic Signals, would depict common tasks, such as the video snippet of a door as the starting point. Video snippets for a software product would be composed of these basic building blocks as well as snippets relating to that specific product, such as a demonstration on how to bold or highlight text in Microsoft Word. Research in to what these snippets are composed of, how they are presented, and how they should interact with each other and the end-user should be conducted by researchers in the disciplines of education and psychology.

Secondly, hypervideo's implementation will require on-screen objects that are moving as well as stationary to link to other hypervideos. Technology similar to that which is used today for graphical images imbedded in hypertext documents could be used for stationary objects in hypervideo documents. Objects that move in a hypervideo, including movement in front of, behind, into, or out of another object in a hypervideo will require development of a technology that can trace their movement across the hypervideo while still retaining the linkage to another hypervideo. Additionally, research on methods to significantly improve the compression of digital images for storage on media or transmission across a network must be conducted. This research will encompass the areas of mathematical compression algorithm development, network protocols, and most likely, a new media for the transmission of data.

4. Analysis

Research from the disciplines of educational psychology and educational training have shown that each individual learns at a difference rate, from a different style, and, retention of the learned subject material is directly related to the manner in which the individual learns the material. Furthermore, the field of psychology has demonstrated, almost a half a century ago, that individuals are limited in the amount of information that they can retain. To this end, Hypervideo is just one example of an end-user software documentation product that meets the established requirements for the educational community, as outlined in Chapter 2 of this thesis, and the desires of the end-user as outlined in Chapter 6, as follows:

1. Utilizes visual stimulus, and removes all ambiguities of language.
2. Stimulates more than one of the senses (sight and touch).
3. Has an indirect feedback loop.
4. Provides task-oriented training.
5. Minimalist in nature and construction.
6. Effectively puts the end-user in control of the speed of delivery of the material, and can be repeated as many times as the end-user desires.

Additionally, from the business aspect, hypervideo could be a tremendous cost savings once the capital investment is regained. With hypervideo only one, universally understood, production set of documentation would be required to be produced vice the multitude of translated end-user documents that must be currently produced by each software developer.

Based upon the results of the survey conducted as part of the research for this thesis, and the research discussed in Chapter 2, the end-user would welcome hypervideo-based documentation. Hypervideo-based documentation would be task-oriented, short, and to the point. Since all language components would be completely removed, ambiguities contributed by the written word would be completely removed. Educational level, or for that matter, reading and comprehension level of the end-user, would no longer be a concern for the developer of the documentation, nor the end-user.

Lastly, for the software developer, the research of this thesis, and others, has shown that the end-user's satisfaction with the software product is directly related to their ability to utilize the product. Hypervideo, being an intuitive interface to the documentation and underlying software product, would definitely improve, according to the research of this thesis and others, the end-user's satisfaction level.

5. Conclusion

This chapter has shown a brief example, based on the knowledge gained from the research conducted for this thesis as well as knowledge gained through researchers in the disciplines of education, psychology, and the cognitive science, of an end-user software documentation product that would meet the requirements of educating the end-user on software products that they utilize. Although there is one pictorially-based software documentation scheme that was used by NASA [HORT94], it is unknown at present how many other documentation products exist that meet, and exceed, the capabilities of the product as described in this chapter. Only further research into the development of effective and efficient end-user documentation by the software development community will tell what other documentation products exist.

When Bush [BUSH45] conceived the idea of hypertext at the end of the Second World War the concepts and ideas utilized to describe hypertext where in the terms of the available technology. Like the petroglyphs of antiquity, Bush's manuscript reached across the boundaries of time to stimulate individuals of a different era. These individuals, utilizing technology that had eventually progressed to the point for the effective and efficient implementation of hypertext, laid the foundations of the Internet, modern international commerce, and information dissemination.

As the world grows smaller with the Internet, and international commerce soars, a dichotomy between the technological advances and the literacy of the world is becoming apparent. International commerce, the Internet, and software in general are presently dependent upon the consumer's educational level. For computer-based technology, and commerce in general, to prosper in a world where the average

educational level appears to be monotonically decreasing, an effective documentation product must be found. Could it be that the walls of cyberspace will, like the caves of antiquity, be covered with petroglyphic representations of tasks and procedures, and thus be the new method of documentation? Unlike the tribal leaders who utilized petroglyphs to convey information because it was the only technology available to themselves and their tribe, petroglyphic information dissemination may become the method of choice for those who seek to communicate with the general populace of the world. Only further research will tell.

Chapter 8

SUMMARY AND CONCLUSIONS

1. Introduction

Presented with the pages of this thesis are conceptual ideas based upon the data obtained from a survey of end-user needs and desires concerning software product documentation. Presented within this chapter is a summary of these ideas and survey results.

2. Thesis Summary

It is clear from the many theses that have been submitted over the years that there are many areas in which the software maintenance activity can be improved upon. As demonstrated within this thesis, studies and papers, have been done on the effect that documentation has on a user's satisfaction with a software application; its ease of use, how quickly a user can learn to use the application, and on how documentation should be standardized. None of these studies or papers focuses on the simple issue that, quite possibly, the documentation just cannot be read or comprehended by the typical user for one or more reasons.

As the world grows smaller, either by individuals traveling around the world or by the Internet with its international reach, the need for a universal standard for end user-level documentation and data display will only grow. How that standard is developed will determine the future of the world, for like the Middle Ages, we may be entering into another era of information haves and information have-nots, solely based on the ability to interact with a computer system application via its documentation and human interface.

Therefore, it is the position of this thesis that the software maintenance community could experience a significant drop in requests for maintenance, if an end-user friendly documentation scheme were to be developed and implemented. A bi-product of this work would be that the end-user community could experience a significant increase in productivity, and satisfaction, with the software product.

3. Results

As depicted in Figure 1-1 of Chapter 1, the contribution that this thesis made to the body of knowledge in software maintenance has been two-fold. First, a model was constructed that incorporated existing theories of the software maintenance process, but concentrated upon improving the satisfaction of the end-user by enhancing the software documentation paradigm based upon the results of a survey conducted on end-user needs and desires. Secondly, an end-user software documentation paradigm designed upon the desires and needs of the end-user was introduced.

Returning to the typical end-user to which this research is directed, and as described in Section 2.1.1 of Chapter 1, we can visualize a change in the manner in which the end-user interacts with the "Help Desk." On their first encounter with the "Help Desk" they will receive an unlabeled, but completely task-oriented, piece of documentation about the specific task which they wish to perform in the software product that they are utilizing. The end-user then "files" this documentation into their own version of the IDP, as discussed in Chapter 4, under whatever title the end-user wishes. As such, the end-user now becomes in control of the manner in which their personal documentation store is constructed, how it is maintained, and moreover, how it is structured. Thus, on subsequent occasions the end-user can easily recover the information required to process a task without re-contacting the "Help Desk."

Notice that the scenario as described above has only one conditional clause in it; that the documentation be task-oriented and unlabeled. As such, the documentation paradigm designed around the needs and desires of the end-user as discussed and described in Chapter 7 becomes a ready component of the new maintenance model.

4. Review of the Criteria for Success

In Chapter 1 a series of criteria for evaluating the successfulness of this thesis was presented. Listed below are these criterion and how each criteria was met:

1. *Address, access, and identify the problems associated with end-user documentation.*

In Chapter 2 of this thesis, a survey of the current literature in the disciplines of software engineering, software maintenance, education and training, and educational psychology was presented. This survey showed that the body of literature within the academic disciplines of computer science, software engineering, and software maintenance is woefully barren on the topic of end-user documentation. Conversely, the academic disciplines of education and training, educational psychology, and psychology have a plethora of research on the effects of poor and inadequate documentation on the end-user, dating back to virtually the advent of the computer age.

Chapter 4 presents a list of 25 hypotheses that were developed upon the research conducted in Chapter 2 of this thesis in respect to the desires and needs of the end-user community in reference to software documentation. Additionally, during the development of these hypotheses, considerable consideration was given to the research conducted in the disciplines of educational psychology, adaptive learning, and the cognitive sciences on the subject of how individuals learn, adapt to new tools and learning environments, and how they retain the skills that they have learned.

2. *Examine current models of the software maintenance process.*

Chapter 2 presents a literature survey of the discipline of software maintenance. During the course of the literature survey, many models of the software maintenance process were reviewed, but only one appeared to adequately model the process in which end-users submit requests for assistance with a software product. This model, the Foster Model, was selected for detailed analysis and subsequent modification in Chapter 4 because of the implication that the Front Desk of the original Foster Model

could be returning documentation products to the end-user, via the Delivery Desk, as a result of that end-user's initial request to the Front Desk.

After modifying the Foster Model, as described in Chapter 4, it became necessary to examine the issue of end-user documentation. Although the software product, as a whole, contains end-user documentation, it became quickly apparent from the available literature that the software maintenance community, as well as most of the computing community, has overlooked the issue of end-user documentation. This oversight was not just limited to how the end-user documentation product should be maintained, but it also included how the documentation product should look, act, and function.

Because of lack of appropriate literature on end-user documentation, maintenance of the product or otherwise, the concept of determining the end-user community's desires and needs concerning this portion of the software product was born. In order to determine the needs and desires of the end-user community, an appropriate tool was required. This tool was the survey that was conducted as part of the research for this thesis.

In order for the tool to be properly developed, a return to the existing literature concerning the software maintenance process was required. On this return, examination of the body of literature showed that the software maintenance community's views about the end-user documentation product could have a serious impact on the end-user. Based upon the views expressed by the software maintainers, as well as views from other academic disciplines, a set of hypotheses was developed about what end-user documentation should be, what it should contain, and how it should function. These hypotheses, thus, became the foundation for the survey questionnaire.

3. *Develop, evaluate, and present a new model of the software maintenance process that incorporates end-user documentation.*

Chapter 4 of this thesis presented an adaptation of the Foster Model, called the Interactive Documentation Program (IDP). This model, the development of which

was based upon several hypotheses about learning, retention of skills, human psychology, and present perceptions and practices in software end-user product documentation, transformed the Front Desk of the Foster Model into an interactive, real-time, documentation source for the end-user. All requests for "actual" software maintenance tasks, such as modifications to the software or corrective actions, are passed through the rest of the model. As such, the focus of the Front Desk in the modified model is now towards improving end-user satisfaction via personalized documentation.

Chapter 5 of this thesis discusses the development and implementation of a survey to collect end-user opinions on software documentation and documentation practices. This survey was conducted via the World-Wide Web, with 300,000 invitations to take the survey distributed worldwide via electronic mail. Of the 300,000 e-mail address utilized, 51,432 turned out to be no longer in use or invalid, leaving 248,568 e-mails that were actually transmitted to individuals, of which 805 individuals responded to the survey, an effective 0.323 percent response rate. Data collection for this survey was conducted via a PERL script, which incorporated controls to ensure that no individual responded more than once to any survey question.

Chapter 6 of this thesis conducted statistical analysis of the data accumulated via the survey against the hypothesis. During this statistical analysis contradictory results to the current literature were obtained. These differences can be explained by the facts that none of the researchers in the literature utilized a sample size as large, nor as geographically diverse, as the one utilized in this thesis.

Several questions on this survey were specifically constructed to collect information from the end-user community on their opinions on the viability of the proposed model and modifications to the Foster Model. This analysis shows that the end-user community would be accepting, if not appreciative, of a change in the methods currently used to provide end-user documentation and solutions to the problems that end-users encounter.

4. *Present an example of an end-user software documentation paradigm that meets the desires and needs of the end-user community.*

Chapter 4 presented several hypotheses on the desires and needs of the end-user community. In Chapter 5, an electronic survey methodology for collecting data to verify these hypotheses was discussed. In Chapter 6, a statistical analysis of these data was performed. Lastly, in Chapter 7, a software documentation paradigm was presented based upon the statistical analysis of the desires and needs of the end-user community.

This analysis showed, in part, that the end-user community was essentially looking for a documentation product that was minimalist in nature and totally task-oriented; in other words, they were wanting a documentation product that told them "how" a task get completed, not "why" the steps they did worked. In addition to this conclusion, numerous other features, as presented in the analysis of the survey in Chapter 6, that the end-users presented as their needs and desires were combined with the results of existing research in the fields of education and psychology to develop the paradigm in Chapter 7.

This paradigm, hypervideo, due to the nature in which it was constructed, meets the expressed desires and needs of the end-user community. Additionally, it capitalizes upon the body of knowledge within the educational and psychological communities to improve the retention of the steps necessary to complete a task within the software product.

5. Retrospective Analysis

5.1 Chapter 1 Revisited

In Section 2.2.1 of Chapter 1, a caricature of the end-user to which this research was directed is presented. This end-user, a generalist who only uses the computer system and its associated software packages in an ancillary role of their primary duties, is a typical representative of the end-users that provided their responses to the survey as described in Chapter 5 and analyzed in Chapter 6.

Based upon the requirements expressed as a result of the analysis of the survey conducted as part of this research, in addition to the prior research conducted by the educational and psychological communities, as discussed in Chapter 2, the resultant paradigm should be sufficiently adequate to provide a means to document "how" to perform a task; the primary goal of such a class of end-users. Since knowing "how" to perform a task is the main desire of the typical end-user, as described in Chapter 1, then, logically speaking, once the end-user knows "how" to perform a task, the subsequent calls to the "Help Desk" of the Foster Model, described in Chapters 2 and 4, should diminish.

For example, let's suppose that an end-user as described in Section 2.2.1 of Chapter 1, as part of their function within an organization, is required to perform certain tasks, such as displaying a graphical representation of data stored in several columns in Microsoft Excel, on an infrequent basis. Clearly, this is a complicated task to many members of the end-user community, and as such, would trigger many requests to the "Help Desk" of the organization.

Under this scenario, the end-user would approach the "Help Desk," as described in Chapter 4, for the task-oriented documentation package which would provide the solution to the problem that they have encountered. Once they have obtained the documentation package, they can then store the package in their own customized IDP. Since the end-user can store the documentation in the IDP in any manner which they desire, such as by task, frequency of use, or product identification, the end-user is now in control of the general maintenance and availability of the documentation. As such, it is believed, the end-user's requests to the "Help Desk" for subsequent occurrences of the same task should be minimized.

Additionally, the research conducted in this thesis is not limited to commercially developed off-the-self software, but could easily be adapted to any in-house, non-mission critical or non-real-time, applications. One such application would be an internally developed human resources software application that tracks employees, their benefits, and their personnel records. Certain tasks within the scope of this application,

such as updating an employee's yearly performance appraisal or providing for the death payment to the employee's survivors, are done on such an infrequent basis that is it conceivably possible that the end-user who uses the software application may forget how do perform these tasks within the application. As such, this application lends itself to the concepts and ideas presented within this thesis.

Like the scenario described about, the end-user would approach the "Help Desk" for an unlabeled, task-oriented, and minimalistic form of documentation on "how" to perform the task. As mentioned above, the end-user would then place this documentation in their personalized IDP for future reference; returning to the "Help Desk" only when a new problem is encountered.

Conversely, though, it could be argued that the documentation paradigm presented is this thesis is based upon faulty assumptions. The discussion of which follows in the next section.

5.2 Thesis Problem Areas

5.2.1 The Thesis Research Problem

In retrospect, the problem of creating a documentation product for the ubiquitous end-user may be just the "tip of the iceberg" of all of the problems associated with the subject matter of this thesis, even if the end-user is strictly limited to being in an office-like environment. Firstly, there is the wide-variety of learning styles, as discussed in Chapter 2, and motivational aspects of the end-user. Secondly, there is the widely diverse general educational level of the end-user community, not to mention the widely diverse specific software product experience level of the end-user community. Thirdly, there is the issue of scale; how far could this concept be applied in the software documentation community? Lastly, the overall cost of implementation of the presented paradigm, and the resultant cost / benefit.

5.2.2 The Survey Questionnaire

Although the survey questionnaire went through a long and complicated development process, it is apparent from several comments that the researcher received that the survey was still too long and possibly too complicated for the majority of the intended

audience. As such, the results presented in this thesis could well possibly be skewed, and as such, the proposed documentation solution presented in Chapter 7 may not be adequate for a widely diverse population base. For example, those individuals that desire to know "why" a process works vice "how" to do the process would not be satisfied with the proposed documentation paradigm. This is because of the fact that the questionnaire was primarily designed upon the results of the literature survey, in Chapter 2, which showed that the majority end-users desire to know "how" to do a task, and were rarely concerned with why the process worked.

Additionally, it could be argued that the manner in which this survey was conducted is suspect to bias, and as such, the resultant analysis and model could be erroneous. This bias can be attributed to many factors.

Firstly, the manner in which the survey was conducted. Individuals were invited to participate in the survey via a random email. As such, it could be argued, this made the survey a self-selected participation on the part of the respondent. This, in general terms, means that those individuals that responded could have had a strong bias, either for or against, the subject of the survey, thus introducing a bias.

Secondly, since the survey was provided only in one language it could be argued that this provided a bias towards individuals whose native language was a form of English and a bias against non-native English speakers.

Thirdly, the redundancy, or restatement of a prior question in a different manner, of some of the questions in the survey could have provided a misleading tone to the questionnaire, or possible confusion on the part of the respondent. Additionally, some, or all, of the contradictory results obtained in the analysis of the survey to other research could be attributed to the manner in which the questions were presented, phrased, or comprehended.

Lastly, the delivery method of the questionnaire could be called into suspect. The questionnaire appeared as one long web page on the respondent's computer. As such, the respondent had to scroll through the survey as they were answering the questions.

This could have been a deterrent for many of the individuals who received the invitation, and as such, it could be argued, only those with a strong bias would complete the survey.

5.2.3 The Documentation Paradigm

Although the model presented in Chapter 7 is designed upon the results of Chapter 6 and the research conducted in Chapter 2, the true viability of the presented paradigm is unknown. Despite the fact that it meets all of the requirements of the research of the educational and psychological communities, it is also designed upon the results of a possibly biased survey of end-users. As such, the class of end-users to which its usefulness may be limited to is the survey respondents themselves. Only full implementation, testing, and subsequent third-party evaluation will tell if the paradigm is actually viable on a large body of end-users.

6. Directions for Further Research

Further research based upon this thesis can be, and is, multi-disciplinary in nature. Several examples of further research, which can be conducted within the disciplines of computer science, software engineering, business, educational psychology, education and training, and the cognitive sciences, are as follows:

I. An implementation of the documentation model, and the IDP in general, to ascertain its effectiveness in an operational capacity should be conducted. Although the IDP, and the corresponding documentation paradigm, was designed around the data provided by the survey of end-user's desires and needs, no field trials were conducted on this design. As such, a multi-disciplinary field trial, to include members from the disciplines of educational psychology and cognitive sciences, should be conducted to ascertain the effectiveness of this paradigm on the end-user community.

II. After implementation, a study to determine if there is an improvement in end-user satisfaction with the software product should be conducted. Although the IDP, and the corresponding documentation paradigm, was

designed around the data provided by the survey of end-user's desires and needs, no field trials were conducted on this design. As such, it is unknown if the end-user, when given a software documentation product in the form of the paradigm described herein, would experience an increase in their satisfaction with the use of the software product.

III. After implementation of the documentation model, and the IDP in general, a study to ascertain the cost / benefit ratio of the model, and software documentation paradigm, in an operational capacity should be conducted. Although the model may prove to be extremely effective from the research study described in I above, the cost of implementation may overshadow any practical advances obtained, hence rendering the model and paradigm useless.

IV. After implementation of the documentation model, and the IDP in general, a study to ascertain the effect of the model on the software maintenance paradigm, as outlined in the Foster Model, should be conducted. Issues to be taken under consideration should include the frequency and comparative analysis of the number of modification requests submitted to the maintenance team. Implementation of the paradigm discussed herein could have one of two effects on the maintenance team: either significantly reduced requests for modifications or corrective actions due to the increased usability of the product by the end-user, or, conversely, significantly increased requests for adaptation or additional enhancements due to the increased understanding of the software product by the end-user.

V. Although the survey presented in this thesis was conducted on a worldwide level, responses to the survey were not equally distributed amongst the various age, educational levels and gender proportions for the geographical locales surveyed. As such, a second survey, with age, gender, and educational levels proportionate to the geographical location should be conducted and

compared to the results of this thesis. Suitable modifications to the IDP and associated documentation paradigm should then be considered and adapted.

VI. Although the survey presented in this thesis was conducted on a worldwide level, only individuals who could communicate in English provided responses to the survey. As such, an additional survey, with translations provided for all of the major languages utilized by software developers for end-user documentation should be conducted and compared to the results of this thesis. Suitable modifications to the IDP and associated documentation paradigm should then be considered and adapted.

VII. The survey presented in this thesis included all forms of end-user documentation, whether it is commercially of the shelf software or in-house developed software. A separate survey should be conducted which limits the surveyed software to commercially available products only, since in-house developed software has a very limited audience. Suitable modifications to the IDP and associated documentation paradigm should then be considered and adapted for the commercially available software.

VIII. Long-term studies on the effectiveness of the documentation paradigm presented in this thesis as a teaching tool for basic software skills, such as document processing and spreadsheet usage, integration into the primary and secondary educational levels should be conducted. As discussed in previous chapters of this thesis, end-user perceptions of the difficulty of use of a software product determine the end-user's satisfaction, and abilities, with the software product. If utilized as a teaching tool, it is foreseeable, based on the data from the survey and research conducted in other academic disciplines, that the documentation paradigm presented in this thesis could have a major affect upon the early utilization, and perceptions, of software products by children.

IX. During the course of the research for this thesis, an informal search of courses offered in the disciplines of computer science and software engineering of higher education institutions within the United Kingdom and United States showed that the development of end-user documentation, as a subject area, is not taught at the baccalaureate level. Development of a multi-discipline, including input from the fields of educational psychology and cognitive sciences, course on the development and implementation of end-user documentation should be considered. Once developed and implemented, the effectiveness of graduates of this program on the satisfaction, usability, and effectiveness of the end-user with the software product should be conducted.

X. Documentation-less, or self-explanatory to the end-user, software development is a logical extension for further research by software engineers seeking to develop a highly productive software product. As software increasingly becomes integrated into the business world, the need for a short "learning curve" will, it is assumed, naturally increase because of the business needs and requirements of remaining productive and competitive in the global market. One manner in which to meet these needs would be the production of a software product that has a "learning curve" that approaches zero.

XI. Chapter 7 indicated some of the desirable features of end-user documentation, and hence will provide an evaluation framework for the development of a product to satisfy the needs of the end-user. Software documentation products that meet these desirable features should be developed and evaluated for their effect on the learning retention and productivity of the end-user.

XII. In concert with item XI above, the issue of scale, and the corresponding cost / benefit analysis should be conducted. That is, does the cost of developing and implementing the model provide enough benefit to the end-user

community so that it is worthwhile to implement this concept on a large-scale basis, such as with a widely-used product such as Microsoft Word?

7. Concluding Remarks

Although this thesis was submitted under the discipline of software engineering, it encompasses a wide body of work conducted in other academic disciplines, such as: cognitive sciences, educational theory and training, educational psychology, and business management (marketing of software products and management information systems). As such, this thesis has assumed an interdisciplinary tone, with aspects from each of the aforementioned disciplines included at various points throughout the pages of this thesis. One major lesson that was learned from the research conducted during this thesis was the absence of fundamental knowledge, such as human - computer interaction, cognitive learning skills, and educational psychology, from these other disciplines in the design and maintenance of the software product.

It is therefore believed that the software engineering and software maintenance communities should undertake a concerted effort to develop an amalgamated, or multi-disciplinary, programming team for the development and maintenance of software products. With such a team, it is believed, the end-user would experience a significant increase in their productivity and satisfaction with software products.

Appendix 1

SAMPLE IDP PRINTED DOCUMENTATION

Figure A1-1

Sample IDP Web Home Page

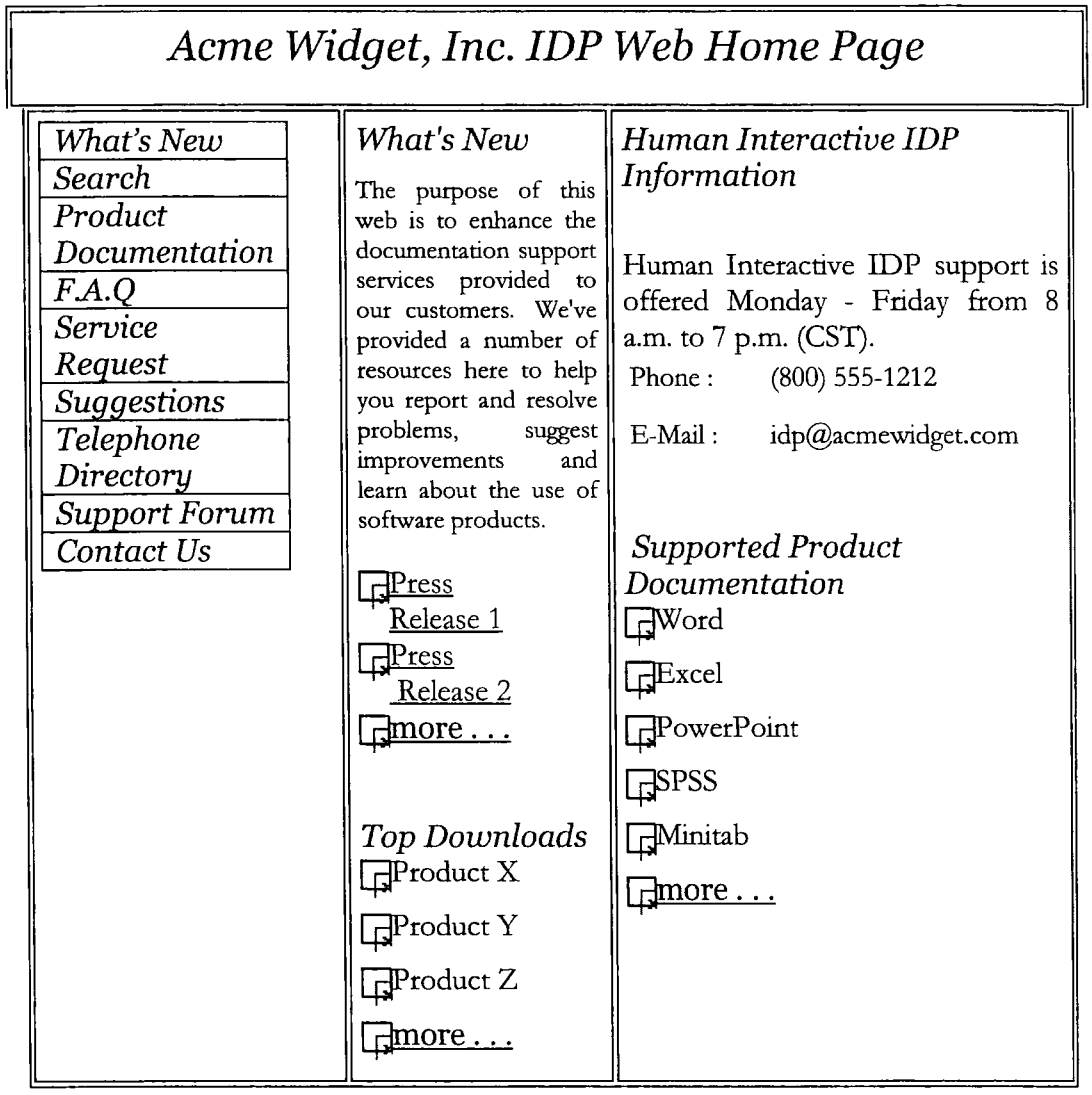


Figure A1-2

Sample Web Page Documentation for Bolding in Microsoft Word [1]

Acme Widget, Inc. IDP Documentation Page

Bolding Text In Microsoft Word

1. Highlight text to be made **BOLD**
2. Click on **BOLD** Icon on Formatting Tool Bar

[1] Items in red are hyperlinks to other pages.

Figure A1-3

Sample IDP "Index Card" for Bolding in Microsoft Word[2]

Bolding Words in Word
1. Highlight text to be made BOLD
2. Click on BOLD Icon on Formatting Tool Bar

[2] Notice personalization of heading for end-user.

Appendix 2

DEMOGRAPHICAL DATA

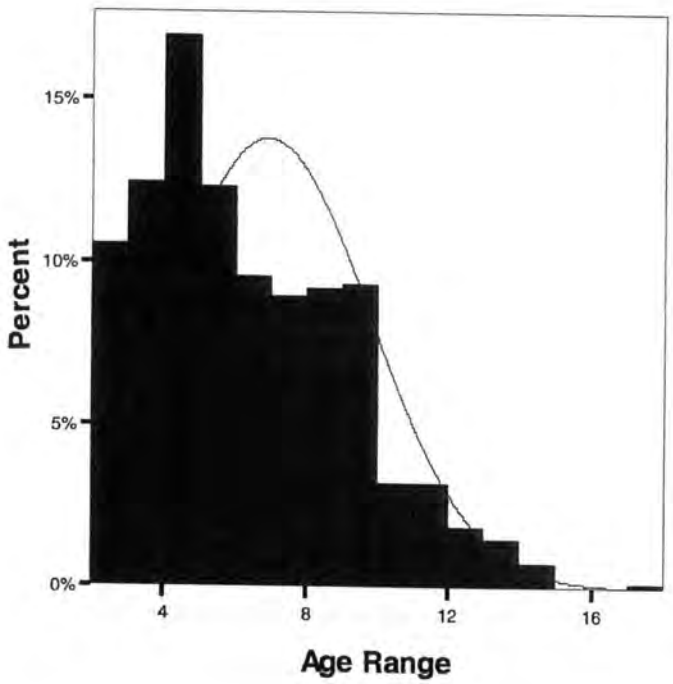
Table 5-1

Age Range * Sex Crosstabulation

		Sex		Total
		Male	Female	
Age Range	**11 to 15**	6	3	9
	16 to 20	53	23	76
	21 to 25	57	43	100
	26 to 30	95	42	137
	31 to 35	75	24	99
	36 to 40	48	29	77
	41 to 45	48	24	72
	46 to 50	55	19	74
	51 to 55	54	21	75
	56 to 60	21	5	26
	61 to 65	19	7	26
	66 to 70	11	4	15
	71 to 75	8	4	12
	76 to 80	5	1	6
	Over 90	0	1	1
Total		555	250	805

Chart 5-1

Age Distribution Compared To The Normal Distribution[1]



[1] Note: The x-axis of the chart is using the numeric responses from the survey corresponding to the age range. Please see the survey for further details.

Table 5-2

Region * Sex Crosstabulation

		Sex		Total
		Male	Female	
Region	North America	404	193	597
	Central America	4	3	7
	South America	5	1	6
	Europe	81	27	108
	Asia	29	5	34
	Africa	2	2	4
	Australia / New Zealand	25	9	34
	South Pacific Islands	1		1
	Elsewhere / Not Listed	4	10	14
Total		**555**	**250**	**805**

Table 5-3

Native Language * Sex Crosstabulation

		Sex		Total
		Male	Female	
Native Language	English (U.S.)	364	179	543
	English (U.K.)	89	33	122
	French	5	5	10
	German	8	2	10
	Spanish	18	1	19
	Italian	3	1	4
	Greek	1		1
	Portuguese	3	2	5
	Russian	2		2
	Cantonese	3	1	4
	Mandarin	6	3	9
	Any African Language	2	1	3
	Any Arabic	2	1	3
	Any Indian Subcontinent	8	5	13
	Not Mentioned	41	16	57
Total		**555**	**250**	**805**

Table 5 – 4

Education * Sex Crosstabulation

		Sex		Total
		Male	Female	
Education	Primary School	2	2	4
	Some Secondary	8	2	10
	Secondary Student	13	9	22
	Secondary Graduate	29	24	53
	Start College but dropped out	36	14	50
	AA Degree	52	24	76
	Presently an Undergraduate	48	20	68
	Completed Most BA/BS Requirements	23	15	38
	College Graduate	123	54	177
	Some Graduate Work	51	11	62
	Presently Graduate Student	30	19	49
	Master's Degree	81	35	116
	Professional Degree	28	14	42
	Quasi-Academic / Professional	5	1	6
	Academic Doctorate	26	6	32
Total		555	250	805

Table 5-5

Degree Field * Sex Crosstabulation

		Sex		Total
		Male	Female	
Degree Field	No Undergraduate Degree	194	97	291
	The Social Sciences	25	29	54
	The Psychological Sciences	17	7	24
	The Letters	32	29	61
	Law, Business / Public Administration	44	15	59
	The Arts	16	21	37
	Engineering	67	7	74
	Natural Science	54	16	70
	Medical Science	15	13	28
	Computer Science	91	16	107
Total		**555**	**250**	**805**

Table 5-6

Native Language * Region Crosstabulation

		Region									Total
		North America	Central America	South America	Europe	Asia	Africa	Australia / New Zealand	South Pacific Islands	Elsewhere / Not Listed	
Native Language	English (U.S.)	519	4		3	4	1	5	1	6	543
	English (U.K.)	37			50	7	1	23		4	122
	French	6			4						10
	German				9	1					10
	Spanish	10	2	4				1		2	19
	Italian				4						4
	Greek				1						1
	Portuguese	2		2	1						5
	Russian	1			1						2
	Cantonese					4					4
	Mandarin	5				3		1			9
	Any African Language	1	1				1				3
	Any Arabic	1					1			1	3
	Any Indian Subcontinent	3			2	7				1	13
	Not Mentioned	12			33	8		4			57
Total		597	7	6	108	34	4	34	1	14	805

Table 5-7

Education * Region Crosstabulation

		Region									Total
		North America	Central America	South America	Europe	Asia	Africa	Australia / New Zealand	South Pacific Islands	Elsewhere / Not Listed	
Education	Primary School	2	1							1	4
	Some Secondary	5			2			2		1	10
	Secondary Student	18	1			1		2			22
	Secondary Graduate	43	1		4		1	2		2	53
	Start College but dropped out	40			8	1				1	50
	AA Degree	65			9			1		1	76
	Presently an Undergraduate	51	2		8	2		4		1	68
	Completed Most BA/BS Requirements	30	2		1	1	1	1		2	38
	College Graduate	132		1	18	14		9	1	2	177
	Some Graduate Work	53			4			5			62
	Presently Graduate Student	34		1	6	3	1	4			49
	Master's Degree	82			22	8		2		2	116
	Professional Degree	22		2	11	3	1	2		1	42
	Quasi-Academic / Professional	6									6
	Academic Doctorate	14		2	15	1					32
Total		597	7	6	108	34	4	34	1	14	805

Table 5-8

Sex * Would American Idiomatic Phrases Hinder the Ability of Non-native Speaking American English Individuals Crosstabulation

		Would American Idiomatic Phrases Hinder the Ability of Non-native Speaking American English Individuals			Total
		Yes	Sometimes	No	
Sex	Male	208	284	63	555
	Female	114	119	17	250
Total		322	403	80	805

Table 5-9

Region * Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals Crosstabulation

		Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals			Total
		Yes	Sometimes	No	
Region	North America	239	305	53	597
	Central America	2	5		7
	South America	5	1		6
	Europe	47	50	11	108
	Asia	11	15	8	34
	Africa	1	2	1	4
	Australia / New Zealand	12	17	5	34
	South Pacific Islands	1			1
	Elsewhere / Not Listed	4	8	2	14
Total		322	403	80	805

Table 5-10

Education * Degree Field Crosstabulation

		Degree Field										Total
		No Undergraduate Degree	The Social Sciences	The Psychological Sciences	The Letters	Law, Business / Public Administration	The Arts	Engineering	Natural Science	Medical Science	Computer Science	
Education	Primary School	1									3	4
	Some Secondary	10										10
	Secondary Student	22										22
	Secondary Graduate	51									2	53
	Start College but dropped out	46			1		1				2	50
	AA Degree	62			1	2	1	2		2	6	76
	Presently an Undergraduate	58	2				2				6	68
	Completed Most BA/BS Requirements	27				1	2	2		1	5	38
	College Graduate	1	19	11	23	26	18	23	22	4	30	177
	Some Graduate Work	9	6	2	11	5	3	10	8	3	5	62
	Presently Graduate Student	3	9	4	4	5	3	9			12	49
	Master's Degree		15	5	16	12	4	17	19	4	24	116
	Professional Degree	1	1		2	7	2	8	1	13	7	42
	Quasi-Academic / Professional		1		1	1	1	1	1			6
	Academic Doctorate		1	2	2			2	19	1	5	32
Total		291	54	24	61	59	37	74	70	28	107	805

Table 5-11

Education * Age Range Crosstabulation

		Education															Total
		Primary School	Some Secondary	Secondary Student	Secondary Graduate	Start College but dropped out	AA Degree	Presently an Undergraduate	Completed Most BA/BS Requirements	College Graduate	Some Graduate Work	Presently Graduate Student	Master's Degree	Professional Degree	Quasi-Academic / Professional	Academic Doctorate	
Age Range	11 to 15	2	3	4		\\\\\\\\											9
	16 to 20			17	17	1	9	27	1			4					76
	21 to 25				3	10	4	24	5	31		13	4	5		1	100
	26 to 30	1	2		5	5	6	7	4	40	9	14	28	9		7	137
	31 to 35		1		6	5	6	3	7	22	9	9	16	9	1	5	99
	36 to 40		1		3	5	10	4	4	20	5	2	14	5	2	2	77
	41 to 45			1	4	4	13	1	5	18	8	1	12	3		2	72
	46 to 50		2		5	9	9	1	5	8	10	2	14	2	1	6	74
	51 to 55				7	4	12	1	2	14	11	1	16	3	1	3	75
	56 to 60						3		1	10	4	2	3	3			26
	61 to 65		1		1	3	1		1	7	1	1	5	1		4	26
	66 to 70				1	1	2		2	3	4			1		1	15
	71 to 75					3			1	1			4	1	1	1	12
	76 to 80				1		1			3	1						6
	Over 90	1															1
Total		4	10	22	53	50	76	68	38	177	62	49	116	42	6	32	805

Table 5-12

Education * Native Language Crosstabulation

		Native Language															Total
		English (U.S.)	English (U.K.)	French	German	Spanish	Italian	Greek	Portuguese	Russian	Cantonese	Mandarin	Any African Language	Any Arabic	Any Indian Subcontinent	Not Mentioned	
Education	Primary School	2											1		1		4
	Some Secondary	6	2													2	10
	Secondary Student	17	2			1					1	1					22
	Secondary Graduate	39	9									1		1	1	2	53
	Start College but dropped out	38	8			1	2									1	50
	AA Degree	59	10			1						1	1			4	76
	Presently an Undergraduate	48	9	1	1	4						2			1	2	68
	Completed Most BA/BS Requirements	31	6									1					38
	College Graduate	118	30	2		4			1		3	2			2	15	177
	Some Graduate Work	52	7	1	1											1	62
	Presently Graduate Student	32	5		1	1		1					1		1	7	49
	Master's Degree	67	17	4	3	4	1			1					5	14	116
	Professional Degree	16	9		2	2	1		2			1		2	1	6	42
	Quasi-Academic / Professional	6															6
	Academic Doctorate	12	8	2	2	1			2	1					1	3	32
Total		543	122	10	10	19	4	1	5	2	4	9	3	3	13	57	805

Table 5-13

Education * Where Computer is Used Crosstabulation

		Where Computer is Used							Total
		At Home	At Work	At School	At Home and School	At Home and Work	At Work and School	At Home, Work, and School	
Education	Primary School			1	1		1	1	4
	Some Secondary	6	2			2			10
	Secondary Student	2	1		11	1		7	22
	Secondary Graduate	14			7	25		7	53
	Start College but dropped out	11	4		1	31		3	50
	AA Degree	18	3		4	42		9	76
	Presently an Undergraduate	9	1		15	2		41	68
	Completed Most BA/BS Requirements	6	3		3	23		3	38
	College Graduate	23	15		5	117		17	177
	Some Graduate Work	4	5		2	49		2	62
	Presently Graduate Student	2	4	1	8	10	2	22	49
	Master's Degree	10	10		2	79	1	14	116
	Professional Degree	12	4			21		5	42
	Quasi-Academic / Professional					3		3	6
	Academic Doctorate	3	4			24		1	32
Total		120	56	2	59	429	4	135	805

Table 5-14

Region * Where Computer is Used Crosstabulation

		Where Computer is Used							Total
		At Home	At Work	At School	At Home and School	At Home and Work	At Work and School	At Home, Work, and School	
Region	North America	97	34	1	40	312		113	**597**
	Central America	1	1	1	1			3	**7**
	South America				1	3		2	**6**
	Europe	9	12		7	70		10	**108**
	Asia	7	5		1	17	2	2	**34**
	Africa					3	1		**4**
	Australia / New Zealand	2	2		7	19		4	**34**
	South Pacific Islands	1							**1**
	Elsewhere / Not Listed	3	2		2	5	1	1	**14**
Total		**120**	**56**	**2**	**59**	**429**	**4**	**135**	**805**

Table 5-15

Sex * Where Computer is Used Crosstabulation

		Where Computer is Used							Total
		At Home	At Work	At School	At Home and School	At Home and Work	At Work and School	At Home, Work, and School	
Sex	Male	73	31	1	30	322	2	96	555
	Female	47	25	1	29	107	2	39	250
Total		120	56	2	59	429	4	135	805

Table 5-16

Age Range * Where Computer is Used Crosstabulation

		Where Computer is Used							Total
		At Home	At Work	At School	At Home and School	At Home and Work	At Work and School	At Home, Work, and School	
Age Range	11 to 15	4			3			2	9
	16 to 20	9	2		30	4		31	76
	21 to 25	13	6		16	31	1	33	100
	26 to 30	9	15	1	2	88	1	21	137
	31 to 35	8	5		4	70		12	99
	36 to 40	6	7		1	50	1	12	77
	41 to 45	12	5			44		11	72
	46 to 50	13	3	1	1	52		4	74
	51 to 55	14	8		1	46		6	75
	56 to 60	4	1			20		1	26
	61 to 65	9	3			12		2	26
	66 to 70	10	1		1	3			15
	71 to 75	7				5			12
	76 to 80	2				4			6
	Over 90						1		1
Total		120	56	2	59	429	4	135	805

Table 5-17

Degree Field * Where Computer is Used Crosstabulation

		Where Computer is Used							Total
		At Home	At Work	At School	At Home and School	At Home and Work	At Work and School	At Home, Work, and School	
Degree Field	No Undergraduate Degree	62	13		41	113		62	291
	The Social Sciences	6	8		3	29	1	7	54
	The Psychological Sciences	3	1			16		4	24
	The Letters	9	8	1	5	29		9	61
	Law, Business / Public Administration	5	5		1	40		8	59
	The Arts	8	3			20		6	37
	Engineering	5	6		6	50		7	74
	Natural Science	9	6			50	1	4	70
	Medical Science	9				17		2	28
	Computer Science	4	6	1	3	65	2	26	107
Total		120	56	2	59	429	4	135	805

Table 5-18

Native Language * Where Computer is Used Crosstabulation

		Where Computer is Used							Total
		At Home	At Work	At School	At Home and School	At Home and Work	At Work and School	At Home, Work, and School	
Native Language	English (U.S.)	88	32	1	42	281	1	98	543
	English (U.K.)	15	9		7	79		12	122
	French	2	2			4		2	10
	German	1	2		1	5		1	10
	Spanish	2	1		1	9		6	19
	Italian		2			2			4
	Greek				1				1
	Portuguese	1				4			5
	Russian					2			2
	Cantonese	1	1		1	1			4
	Mandarin	3			2	2		2	9
	Any African Language			1		1	1		3
	Any Arabic				1	2			3
	Any Indian Subcontinent	2	2			6	1	2	13
	Not Mentioned	5	5		3	31	1	12	57
Total		120	56	2	59	429	4	135	805

Table 5-19

Native Language * Documentation In Native Language Crosstabulation

		Documentation in Native Language		Total
		Yes	No	
Native Language	English (U.S.)	518	25	543
	English (U.K.)	109	13	122
	French	6	4	10
	German	8	2	10
	Spanish	7	12	19
	Italian	2	2	4
	Greek	1		1
	Portuguese	1	4	5
	Russian	1	1	2
	Cantonese	3	1	4
	Mandarin	2	7	9
	Any African Language		3	3
	Any Arabic	1	2	3
	Any Indian Subcontinent	1	12	13
	Not Mentioned	22	35	57
Total		682	123	805

Table 5-20

Sex * Involved In Software Development, Maintenance Or Sales Crosstabulation

		Involved In Software Development, Maintenance Or Sales							Total
		Develop or maintain software applications	Write software documentation	Provide Help Desk Support Functions	Sell software	Management of computer functions	Teach computers	None of the above	
Sex	Male	133	14	39	10	78	51	230	555
	Female	19	9	7	2	20	17	176	250
Total		152	23	46	12	98	68	406	805

Table 5-21

Education * Involved In Software Development, Maintenance Or Sales Crosstabulation

		Involved In Software Development, Maintenance Or Sales							Total
		Develop or maintain software applications	Write software documentation	Provide Help Desk Support Functions	Sell software	Management of computer functions	Teach computers	None of the above	
Education	Primary School	1	1	1				1	4
	Some Secondary					2	1	7	10
	Secondary Student		1			1	1	19	22
	Secondary Graduate	7	1	6		7	1	31	53
	Start College but dropped out	6		7		9	1	27	50
	AA Degree	7	1	6		10	6	46	76
	Presently an Undergraduate	14		4	1	5	6	38	68
	Completed Most BA/BS Requirements	7	2	4	1	5	4	15	38
	College Graduate	41	4	8	4	28	15	77	177
	Some Graduate Work	12	5	3	4	10	7	21	62
	Presently Graduate Student	9	1	3		4	7	25	49
	Master's Degree	31	5	3	1	12	12	52	116
	Professional Degree	8			1	4	2	27	42
	Quasi-Academic / Professional					1	1	4	6
	Academic Doctorate	9	2	1			4	16	32
Total		152	23	46	12	98	68	406	805

Table 5-22

Involved In Software Development, Maintenance Or Sales *Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals Crosstabulation

		Involved In Software Development, Maintenance Or Sales *Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals			Total
		Yes	Sometimes	No	
Involved in Software Development, Maintenance or Sales	Develop or maintain software applications	63	73	16	152
	Write software documentation	7	13	3	23
	Provide Help Desk Support Functions	21	16	9	46
	Sell software	6	5	1	12
	Management of computer functions	42	44	12	98
	Teach computers	30	32	6	68
	None of the above	153	220	33	406
Total		322	403	80	805

Table 5-23

Involved in Software Development, Maintenance or Sales * Degree Field Crosstabulation

		Degree Field										Total
		No Undergraduate Degree	The Social Sciences	The Psychological Sciences	The Letters	Law, Business / Public Administration	The Arts	Engineering	Natural Science	Medical Science	Computer Science	
Involved in Software Development, Maintenance or Sales	Develop or maintain software applications	35	3	5	6	9	5	16	20	1	52	152
	Write software documentation	6	2		6	1	1	2	3		2	23
	Provide Help Desk Support Functions	21	2		2	2	3		3	5	8	46
	Sell software	3	2		1	1		3			2	12
	Management of computer functions	37	5		3	9	3	16	7	3	15	98
	Teach computers	16	9	3	7	5	4	4	4	1	15	68
	None of the above	173	31	16	36	32	21	33	33	18	13	406
Total		291	54	24	61	59	37	74	70	28	107	805

Table 5-24

Multi-dimensional Crosstabulation

	Sex																			
	Male										Female									
	Degree Field										Degree Field									
	No Under-graduate Degree	The Social Sciences	The Psychological Sciences	The Letters	Law, Business / Public Administration	The Arts	Engineering	Natural Science	Medical Science	Computer Science	No Undergraduate Degree	The Social Sciences	The Psychological Sciences	The Letters	Law, Business / Public Administration	The Arts	Engineering	Natural Science	Medical Science	Computer Science
	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education	Education
	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count
Primary School										2	1									1
Some Secondary	8										2									
Secondary Student	13										9									
Secondary Graduate	27									2	24									
Start College but dropped out	33			1						2	13					1				
AA Degree	41				2		2		1	6	21			1		1			1	
Presently an Undergraduate	45									3	13	2				2				3
Completed Most BA/BS Requirements	16					1	2			4	11				1	1			1	1
College Graduate	1	9	8	13	20	9	22	15		26		10	3	10	6	9	1	7	4	4
Some Graduate Work	8	2	2	7	4	2	10	8	3	5	1	4		4	1	1				
Presently Graduate Student	2	4	1	1	3	2	7			10	1	5	3	3	2	1	2			2
Master's Degree		8	5	7	9		15	13	3	21		7		9	3	4	2	6	1	3
Professional Degree		1		1	6	1	7		7	5	1			1	1	1	1	1	6	2
Quasi-Academic / Professional		1		1		1	1	1							1					
Academic Doctorate			1	1			1	17	1	5		1	1	1			1	2		

Table 5-25

Sex * Do you use the computer to play games Crosstabulation

		Do you use the computer to play games				Total
		Frequently	Sometimes	Not Often	Never	
Sex	Male	127	193	166	69	555
	Female	44	87	84	35	250
Total		171	280	250	104	805

Table 5-26

Multidimensional Crosstabulation

		Sex							
		Male				Female			
		Do you use the computer to play games?				Do you use the computer to play games?			
		Frequently	Sometimes	Not Often	Never	Frequently	Sometimes	Not Often	Never
Age Range	11 to 15	4	2			1	2		
	16 to 20	33	18	2		6	9	8	
	21 to 25	28	19	7	3	5	15	20	3
	26 to 30	21	43	22	9	8	7	19	8
	31 to 35	13	30	27	5	3	11	8	2
	36 to 40	6	21	18	3	5	11	6	7
	41 to 45	6	11	23	8	3	9	8	4
	46 to 50	5	15	27	8	3	9	5	2
	51 to 55	8	16	19	11	3	8	5	5
	56 to 60		6	7	8		1	1	3
	61 to 65	2	5	7	5	3	2	1	1
	66 to 70	1	3	4	3	1	3		
	71 to 75		3	1	4	2		2	
	76 to 80		1	2	2			1	
	Over 90					1			

Table 5-27

Multidimensional Crosstabulation

		Sex							
		Male				Female			
		Do you use the computer to play games?				Do you use the computer to play games?			
		Frequently	Sometimes	Not Often	Never	Frequently	Sometimes	Not Often	Never
Education	Primary School	1	1			2			
	Some Secondary	5	2	1			2		
	Secondary Student	6	6	1		3	4	2	
	Secondary Graduate	11	10	7	1	6	10	7	1
	Start College but dropped out	7	13	13	3	5	5	3	1
	AA Degree	14	21	12	5	3	13	6	2
	Presently an Undergraduate	23	18	6	1	1	8	8	3
	Completed Most BA/BS Requirements	2	4	12	5	3	6	5	1
	College Graduate	24	46	38	15	8	22	20	4
	Some Graduate Work	6	21	18	6	5	3		3
	Presently Graduate Student	11	10	6	3	2	4	12	1
	Master's Degree	13	23	31	14	3	7	15	10
	Professional Degree	2	9	11	6	2	3	3	6
	Quasi-Academic / Professional		3	1	1	1			
	Academic Doctorate	2	6	9	9			3	3

Table 5-28

Age Range * Do You Use The Computer To Play Games? Crosstabulation

		Do You Use The Computer To Play Games?				Total
		Frequently	Sometimes	Not Often	Never	
Age Range	11 to 15	5	4			9
	16 to 20	39	27	10		76
	21 to 25	33	34	27	6	100
	26 to 30	29	50	41	17	137
	31 to 35	16	41	35	7	99
	36 to 40	11	32	24	10	77
	41 to 45	9	20	31	12	72
	46 to 50	8	24	32	10	74
	51 to 55	11	24	24	16	75
	56 to 60		7	8	11	26
	61 to 65	5	7	8	6	26
	66 to 70	2	6	4	3	15
	71 to 75	2	3	3	4	12
	76 to 80		1	3	2	6
	Over 90	1				1
Total		171	280	250	104	805

Table 5-29

Degree Field * Do You Use The Computer To Play Games? Crosstabulation

		Do you use the computer to play games?				Total
		Frequently	Sometimes	Not Often	Never	
Degree Field	No Undergraduate Degree	91	110	67	23	**291**
	The Social Sciences	5	25	16	8	**54**
	The Psychological Sciences	2	8	10	4	**24**
	The Letters	13	13	19	16	**61**
	Law, Business / Public Administration	6	25	20	8	**59**
	The Arts	3	12	18	4	**37**
	Engineering	13	19	28	14	**74**
	Natural Science	7	18	30	15	**70**
	Medical Science	4	11	7	6	**28**
	Computer Science	27	39	35	6	**107**
Total		**171**	**280**	**250**	**104**	**805**

Table 5-30

Education * Do You Use The Computer To Play Games? Crosstabulation

		Do You Use The Computer To Play Games?				Total
		Frequently	Sometimes	Not Often	Never	
Education	Primary School	3	1			4
	Some Secondary	5	4	1		10
	Secondary Student	9	10	3		22
	Secondary Graduate	17	20	14	2	53
	Start College but dropped out	12	18	16	4	50
	AA Degree	17	34	18	7	76
	Presently an Undergraduate	24	26	14	4	68
	Completed Most BA/BS Requirements	5	10	17	6	38
	College Graduate	32	68	58	19	177
	Some Graduate Work	11	24	18	9	62
	Presently Graduate Student	13	14	18	4	49
	Master's Degree	16	30	46	24	116
	Professional Degree	4	12	14	12	42
	Quasi-Academic / Professional	1	3	1	1	6
	Academic Doctorate	2	6	12	12	32
Total		171	280	250	104	805

Table 5-31

Native Language * Do You Use The Computer To Play Games? Crosstabulation

		Do You Use The Computer To Play Games?				Total
		Frequently	Sometimes	Not Often	Never	
Native Language	English (U.S.)	124	187	168	64	543
	English (U.K.)	28	43	31	20	122
	French		3	5	2	10
	German	1	2	7		10
	Spanish	4	7	6	2	19
	Italian		1	1	2	4
	Greek		1			1
	Portuguese		1	1	3	5
	Russian		1	1		2
	Cantonese		2	2		4
	Mandarin	2	5	2		9
	Any African Language		2	1		3
	Any Arabic		2	1		3
	Any Indian Subcontinent	2	5	5	1	13
	Not Mentioned	10	18	19	10	57
Total		171	280	250	104	805

Table 5-32

Documentation With Computer Games * Sex Crosstabulation

		Sex		Total
		Male	Female	
Documentation with computer games	I do not use computer games	94	48	142
	Just as difficult as other computer documentation	98	41	139
	Not as difficult	75	36	111
	Somewhat easier	89	52	141
	Much easier	65	15	80
	Don't need	134	58	192
Total		555	250	805

Table 5-33

Difficulty Using Automated Teller Machines * Sex Crosstabulation

		Sex		Total
		Male	Female	
Difficulty using Automated Teller Machines	Yes	6	2	8
	Sometimes	34	14	48
	No	515	234	749
Total		**555**	**250**	**805**

Table 5-34

Age Range * Difficulty Using Automated Teller Machines Crosstabulation

		Difficulty Using Automated Teller Machines			Total
		Yes	Sometimes	No	
Age Range	11 to 15		1	8	9
	16 to 20		5	71	76
	21 to 25		8	92	100
	26 to 30	1	6	130	137
	31 to 35		5	94	99
	36 to 40	2	3	72	77
	41 to 45		3	69	72
	46 to 50		7	67	74
	51 to 55	2	4	69	75
	56 to 60	2	1	23	26
	61 to 65		4	22	26
	66 to 70		1	14	15
	71 to 75			12	12
	76 to 80			6	6
	Over 90	1			1
Total		**8**	**48**	**749**	**805**

Table 5-35

Education * Difficulty Using Automated Teller Machines Crosstabulation

		Difficulty Using Automated Teller Machines			Total
		Yes	Sometimes	No	
Education	Primary School	1		3	4
	Some Secondary			10	10
	Secondary Student		2	20	22
	Secondary Graduate		2	51	53
	Start College but dropped out		2	48	50
	AA Degree	1	2	73	76
	Presently an Undergraduate	1	6	61	68
	Completed Most BA/BS Requirements		1	37	38
	College Graduate	1	9	167	177
	Some Graduate Work			62	62
	Presently Graduate Student		4	45	49
	Master's Degree	2	12	102	116
	Professional Degree	1	2	39	42
	Quasi-Academic / Professional	1		5	6
	Academic Doctorate		6	26	32
Total		8	48	749	805

Table 5-36

Degree Field * Difficulty Using Automated Teller Machines Crosstabulation

		Difficulty Using Automated Teller Machines			Total
		Yes	Sometimes	No	
Degree Field	No Undergraduate Degree	2	10	279	291
	The Social Sciences		4	50	54
	The Psychological Sciences	1	2	21	24
	The Letters		7	54	61
	Law, Business / Public Administration		3	56	59
	The Arts		1	36	37
	Engineering	1	2	71	74
	Natural Science	2	7	61	70
	Medical Science	1	3	24	28
	Computer Science	1	9	97	107
Total		8	48	749	805

Table 5-37

Do You Find Software Documentation Easy To Comprehend? * Sex Crosstabulation

		Sex		Total
		Male	Female	
Do You Find Software Documentation Easy To Comprehend?	Yes	88	15	103
	Sometimes	338	162	500
	Not often	118	64	182
	No	11	9	20
Total		555	250	805

Table 5-38

Education * Do You Find Software Documentation Easy To Comprehend? Crosstabulation

		Do You Find Software Documentation Easy To Comprehend?				Total
		Yes	Sometimes	Not often	No	
Education	Primary School	1	3			4
	Some Secondary		6	4		10
	Secondary Student	4	14	4		22
	Secondary Graduate	6	37	8	2	53
	Start College but dropped out	7	33	10		50
	AA Degree	9	47	17	3	76
	Presently an Undergraduate	9	45	14		68
	Completed Most BA/BS Requirements	6	19	11	2	38
	College Graduate	24	114	38	1	177
	Some Graduate Work	4	37	17	4	62
	Presently Graduate Student	8	34	5	2	49
	Master's Degree	14	68	31	3	116
	Professional Degree	5	29	8		42
	Quasi-Academic / Professional		3	3		6
	Academic Doctorate	6	11	12	3	32
Total		103	500	182	20	805

Table 5-39

Degree Field * Do You Find Software Documentation Easy To Comprehend? Crosstabulation

		Do You Find Software Documentation Easy To Comprehend?				Total
		Yes	Sometimes	Not often	No	
Degree Field	No Undergraduate Degree	40	184	63	4	291
	The Social Sciences	6	35	12	1	54
	The Psychological Sciences	2	16	4	2	24
	The Letters	7	33	19	2	61
	Law, Business / Public Administration	7	33	16	3	59
	The Arts	1	27	8	1	37
	Engineering	12	43	17	2	74
	Natural Science	11	37	19	3	70
	Medical Science	1	19	7	1	28
	Computer Science	16	73	17	1	107
Total		**103**	**500**	**182**	**20**	**805**

Table 5-40

Comfort Level Using A Computer * Sex Crosstabulation[1]

		Sex		Total
		Male	Female	
Comfort level using a computer	1	212	40	**252**
	2	85	31	**116**
	3	36	24	**60**
	4	19	18	**37**
	5	21	15	**36**
	6	8	16	**24**
	7	17	27	**44**
	8	27	24	**51**
	9	54	26	**80**
	10	76	29	**105**
Total		**555**	**250**	**805**

[1] With 1 being Extremely Comfortable to 10 being Extremely Uncomfortable

Table 5-41

Sex * Improve User Document Impact Your Ability Crosstabulation

		Improve User Document Impact Your Ability			Total
		Yes	Possibly	No	
Sex	Male	281	227	47	555
	Female	102	137	11	250
Total		383	364	58	805

Table 5-42

Computer Use Primary Function Of Your Work * Sex Crosstabulation

		Sex		Total
		Male	Female	
Computer Use Primary Function Of Your Work	Yes	416	165	581
	No	139	85	224
Total		555	250	805

Table 5-43

When You First Utilize A Software Package, What Are You Most Likely To Do? * Sex Crosstabulation

		Sex		Total
		Male	Female	
When You First Utilize A Software Package, What Are You Most Likely To Do?	Read all documentation and tutorials	28	11	39
	Read some documentation and tutorials	131	85	216
	Read all documentation	20	2	22
	Read all tutorials	5	6	11
	Read some documentation	110	44	154
	Read some tutorials	45	35	80
	Read nothing	216	67	283
Total		555	250	805

Table 5-44

Sex * Utilized After-Market Materials Crosstabulation

		Utilized After-Market Materials		Total
		Yes	No	
Sex	Male	331	224	555
	Female	131	119	250
Total		462	343	805

Table 5-45

Education * Utilized After-Market Materials Crosstabulation

		Utilized After-Market Materials		Total
		Yes	No	
Education	Primary School	1	3	4
	Some Secondary	3	7	10
	Secondary Student	7	15	22
	Secondary Graduate	22	31	53
	Start College but dropped out	20	30	50
	AA Degree	46	30	76
	Presently an Undergraduate	32	36	68
	Completed Most BA/BS Requirements	20	18	38
	College Graduate	115	62	177
	Some Graduate Work	49	13	62
	Presently Graduate Student	25	24	49
	Master's Degree	81	35	116
	Professional Degree	24	18	42
	Quasi-Academic / Professional	4	2	6
	Academic Doctorate	13	19	32
Total		462	343	805

Table 5-25

Sex * Do you use the computer to play games Crosstabulation

		Do you use the computer to play games				Total
		Frequently	Sometimes	Not Often	Never	
Sex	Male	127	193	166	69	555
	Female	44	87	84	35	250
Total		171	280	250	104	805

Table 5-26

Multidimensional Crosstabulation

		Sex							
		Male				Female			
		Do you use the computer to play games?				Do you use the computer to play games?			
		Frequently	Sometimes	Not Often	Never	Frequently	Sometimes	Not Often	Never
Age Range	11 to 15	4	2			1	2		
	16 to 20	33	18	2		6	9	8	
	21 to 25	28	19	7	3	5	15	20	3
	26 to 30	21	43	22	9	8	7	19	8
	31 to 35	13	30	27	5	3	11	8	2
	36 to 40	6	21	18	3	5	11	6	7
	41 to 45	6	11	23	8	3	9	8	4
	46 to 50	5	15	27	8	3	9	5	2
	51 to 55	8	16	19	11	3	8	5	5
	56 to 60		6	7	8		1	1	3
	61 to 65	2	5	7	5	3	2	1	1
	66 to 70	1	3	4	3	1	3		
	71 to 75		3	1	4	2		2	
	76 to 80		1	2	2			1	
	Over 90					1			

Table 5-27

Multidimensional Crosstabulation

		Sex							
		Male				Female			
		Do you use the computer to play games?				Do you use the computer to play games?			
		Frequently	Sometimes	Not Often	Never	Frequently	Sometimes	Not Often	Never
Education	Primary School	1	1			2			
	Some Secondary	5	2	1			2		
	Secondary Student	6	6	1		3	4	2	
	Secondary Graduate	11	10	7	1	6	10	7	1
	Start College but dropped out	7	13	13	3	5	5	3	1
	AA Degree	14	21	12	5	3	13	6	2
	Presently an Undergraduate	23	18	6	1	1	8	8	3
	Completed Most BA/BS Requirements	2	4	12	5	3	6	5	1
	College Graduate	24	46	38	15	8	22	20	4
	Some Graduate Work	6	21	18	6	5	3		3
	Presently Graduate Student	11	10	6	3	2	4	12	1
	Master's Degree	13	23	31	14	3	7	15	10
	Professional Degree	2	9	11	6	2	3	3	6
	Quasi-Academic / Professional		3	1	1	1			
	Academic Doctorate	2	6	9	9			3	3

Table 5-46

Is Software Documentation An Afterthought Of The Software Developer? * Sex Crosstabulation[2]

		Sex		Total
		Male	Female	
Is Software Documentation An Afterthought Of The Software Developer?	1	26	10	36
	2	50	16	66
	3	100	39	139
	4	73	36	109
	5	94	63	157
	6	62	32	94
	7	79	26	105
	8	55	16	71
	9	10	7	17
	10	6	5	11
Total		555	250	805

Table 5-47

Rating of Vendor Supplied Software Documentation * Sex Crosstabulation[3]

		Sex		Total
		Male	Female	
Rating of Vendor Supplied Software Documentation	1	6	5	11
	2	13	13	26
	3	75	27	102
	4	68	30	98
	5	106	65	171
	6	74	26	100
	7	114	39	153
	8	67	34	101
	9	23	9	32
	10	9	2	11
Total		555	250	805

[2] With 1 representing Total After Thought to 10 representing Fully Planned

[3] With 1 representing Totally Useless to 10 representing Extremely Helpful

Table 5-48

Does Gender Specific Terminology Effect Your Ability To Use A Software Product? * Sex Crosstabulation

		Sex		Total
		Male	Female	
Does Gender Specific Terminology Effect Your Ability To Use A Software Product?	Yes	31	13	44
	Sometimes	52	45	97
	No	472	192	664
Total		555	250	805

Table 5-49

Do You Believe That Software Manufacturers Purposely Create An Aftermarket? * Sex Crosstabulation

		Sex		Total
		Male	Female	
Do You Believe That Software Manufacturers Purposely Create An Aftermarket?	Yes	123	73	196
	Maybe	225	112	337
	No	207	65	272
Total		555	250	805

Table 5-50

Do Menu-based Systems Help Or Hinder? * Sex Crosstabulation

		Sex		Total
		Male	Female	
Do Menu-based Systems Help Or Hinder?	Help	487	223	710
	Hinder	68	27	95
Total		555	250	805

Table 5-51

Would More Picture Examples Of Expected Results Help? * Sex Crosstabulation

		Sex		Total
		Male	Female	
Would More Picture Examples Of Expected Results Help?	Yes	282	144	426
	Maybe	240	92	332
	No	33	14	47
Total		555	250	805

Table 5-52

Would A More intuitive User Interface Improve Productivity? * Sex Crosstabulation

		Sex		Total
		Male	Female	
Would A More intuitive User Interface Improve Productivity?	Yes	353	133	486
	Maybe	183	111	294
	No	19	6	25
Total		555	250	805

Table 5-53

Average Response Time From A Help Desk * Sex Crosstabulation

		Sex		Total
		Male	Female	
Average Response Time From A Help Desk	I do not report bugs	228	132	360
	Less than 30 minutes	28	16	44
	Less than 1 hour	21	11	32
	Less than 2 hours	13	9	22
	Less than 4 hours	9	7	16
	Less than 6 hours	3	1	4
	Less than 8 hours	17	8	25
	Greater than 1 business day	236	66	302
Total		555	250	805

Table 5-54

What Do You Do When You Encounter A Problem With Software? * Sex Crosstabulation

		Sex		Total
		Male	Female	
What Do You Do When You Encounter A Problem With Software?	Pick up printed User Documentation	170	74	244
	Utilize on-line Help	235	64	299
	Call a friend	91	83	174
	Call the software vendor	49	22	71
	None of the above	10	7	17
Total		555	250	805

Table 5-55

Satisfaction With User Documentation * Sex Crosstabulation[4]

		Sex		Total
		Male	Female	
Satisfaction With User Documentation	1	9	3	12
	2	14	9	23
	3	80	30	110
	4	64	24	88
	5	132	65	197
	6	69	37	106
	7	84	36	120
	8	73	32	105
	9	23	12	35
	10	7	2	9
Total		555	250	805

[4] With 1 representing Extremely Satisfied to 10 representing Extremely Dissatisfied

Appendix 3

HYPOTHESIS TESTING

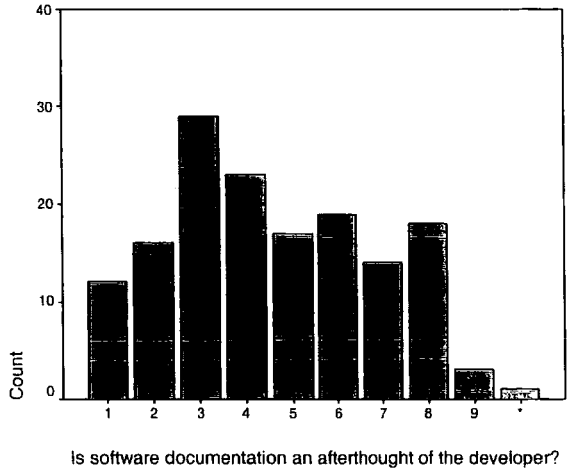
Table 6-H1-1

Involvement in Computer Industry

	Frequency
Develop or maintain software applications	152
Write software documentation	23
Provide Help Desk Support Functions	46
Sell software	12
Management of computer functions	98
Teach computers	68
Total	399

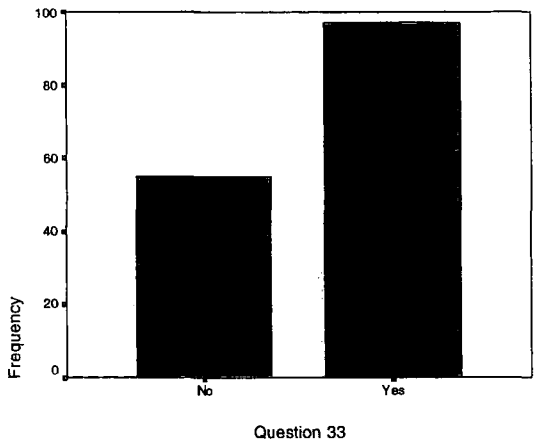
-Graph 6-H1-1

Distribution Of Reponses Of Individuals Employed As Software Developers Or Maintainers To Question 33



Graph 6-H1-2

Distribution Of Reponses Of Individuals Employed As Software Developers Or Maintainers To Question



33

Table 6-H2-1

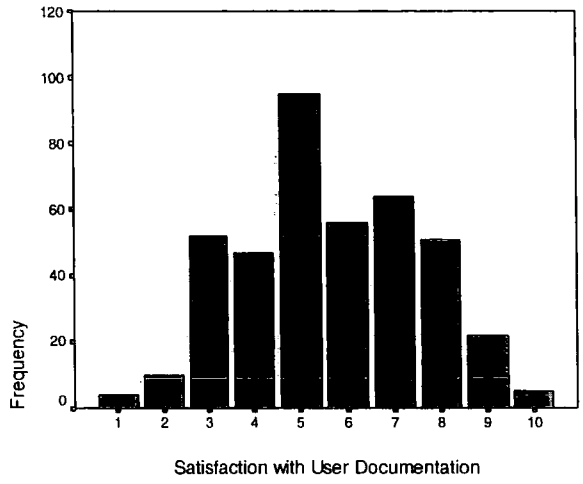
Satisfaction with User Documentation By End-Users[1]

	Frequency	Percent	Valid Percent	Cumulative Percent
1	4	1.0	1.0	1.0
2	10	2.5	2.5	3.4
3	52	12.8	12.8	16.3
4	47	11.6	11.6	27.8
5	95	23.4	23.4	51.2
6	56	13.8	13.8	65.0
7	64	15.8	15.8	80.8
8	51	12.6	12.6	93.3
9	22	5.4	5.4	98.8
10	5	1.2	1.2	100.0
Total	**406**	**100.0**	**100.0**	

[1] With 1 representing Extremely Satisfied and 10 representing Extremely Dissatisfied

Graph 6-H2-1

Satisfaction With User Documentation By End-Users[2]



Graph 6-H2-2

End-User Satisfied With Documentation?

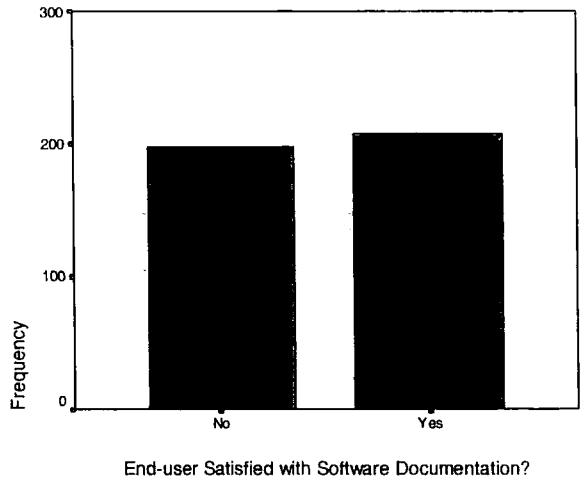


Table 6-H3-1

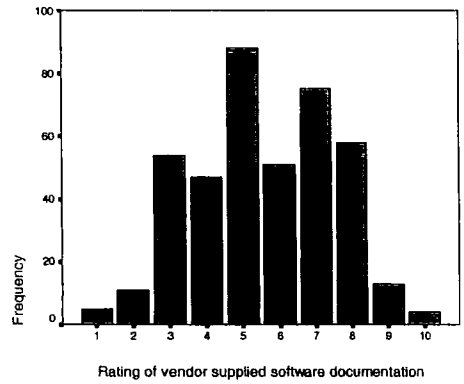
[2] With 1 representing Extremely Satisfied and 10 representing Extremely Dissatisfied

Rating of Vendor Supplied Software Documentation[3]

	Frequency	Percent	Valid Percent	Cumulative Percent
1	5	1.2	1.2	1.2
2	11	2.7	2.7	3.9
3	54	13.3	13.3	17.2
4	47	11.6	11.6	28.8
5	88	21.7	21.7	50.5
6	51	12.6	12.6	63.1
7	75	18.5	18.5	81.5
8	58	14.3	14.3	95.8
9	13	3.2	3.2	99.0
10	4	1.0	1.0	100.0
Total	**406**	**100.0**	**100.0**	

Graph 6-H3-1

Rating Of Vendor Supplied Software Documentation[4]



[3] With 1 representing Totally Useless to 10 representing Extremely Helpful

[4] With 1 representing Totally Useless to 10 representing Extremely Helpful

Graph 6-H3-2

Rating Of Vendor Supplied Software Documentation

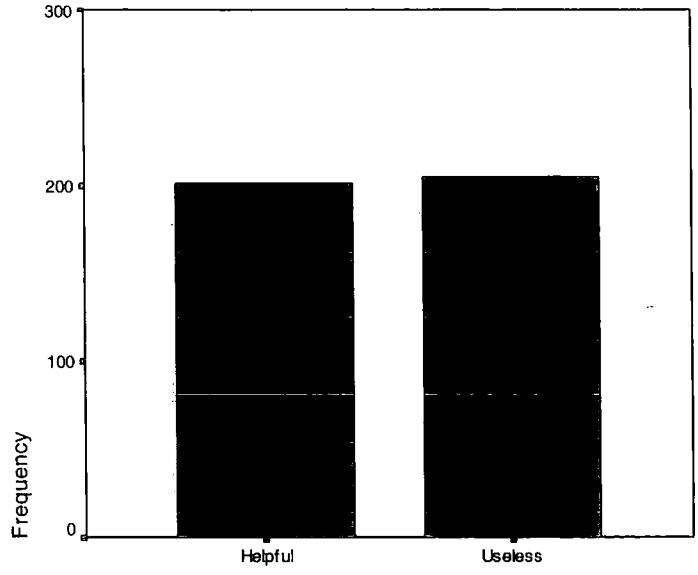


Table 6-4H-1

Do You Posses the Most Recent Edition Of The User Documentation For The Software You Utilize?

		Frequency	Percent	Valid Percent	Cumulative Percent
Extremely Confident	1	31	3.9	3.9	3.9
	2	64	8.0	8.0	11.8
	3	108	13.4	13.4	25.2
	4	66	8.2	8.2	33.4
	5	142	17.6	17.6	51.1
	6	74	9.2	9.2	60.2
	7	78	9.7	9.7	69.9
	8	91	11.3	11.3	81.2
	9	78	9.7	9.7	90.9
Extremely Unconfident	10	73	9.1	9.1	100.0
	Total	805	100.0	100.0	

Table 6-H5-1

Involved In Software Development, Maintenance Or Sales

	Frequency	Percent	Valid Percent	Cumulative Percent
Develop or maintain software applications	152	18.9	18.9	18.9
Write software documentation	23	2.9	2.9	21.7
Provide Help Desk Support Functions	46	5.7	5.7	27.5
Sell software	12	1.5	1.5	28.9
Management of computer functions	98	12.2	12.2	41.1
Teach computers	68	8.4	8.4	49.6
None of the above	406	50.4	50.4	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H5-2

Is Software Documentation An afterthought Of The Software Developer? [5]

	Frequency	Percent	Valid Percent	Cumulative Percent
1	13	3.2	3.2	3.2
2	27	6.7	6.7	9.9
3	61	15.0	15.0	24.9
4	59	14.5	14.5	39.4
5	92	22.7	22.7	62.1
6	49	12.1	12.1	74.1
7	57	14.0	14.0	88.2
8	33	8.1	8.1	96.3
9	11	2.7	2.7	99.0
10	4	1.0	1.0	100.0
Total	**406**	**100.0**	**100.0**	

Table 6-H6-1

[5] Involved in Software Development, Maintenance or Sales = None of the above

Do You Believe That Software Manufacturers Purposely Create Inferior Documentation?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	196	24.3	24.3	24.3
Maybe	337	41.9	41.9	66.2
No	272	33.8	33.8	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H7-1

: Impact Of Documentation On The End-User's Ability To Utilize A Computer

		Frequency	Percent	Valid Percent	Cumulative Percent
No Impact	1	44	5.5	5.5	5.5
	2	60	7.5	7.5	12.9
	3	96	11.9	11.9	24.8
	4	92	11.4	11.4	36.3
	5	127	15.8	15.8	52.0
	6	78	9.7	9.7	61.7
	7	107	13.3	13.3	75.0
	8	109	13.5	13.5	88.6
	9	44	5.5	5.5	94.0
Extreme Impact	10	48	6.0	6.0	100.0
	Total	**805**	**100.0**	**100.0**	

Table 6-H8-1

Removal Of Which Documentation Product Would Hinder Your Ability To Utilize A Computer?

	Frequency	Percent	Valid Percent	Cumulative Percent
Icons	153	19.0	19.0	19.0
On-line Help	119	14.8	14.8	33.8
Printed User's Manuals	161	20.0	20.0	53.8
Wizards	174	21.6	21.6	75.4
Removal of any	198	24.6	24.6	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H9-1

Do You Believe That Software Manufacturers Purposely Create An Aftermarket?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	196	24.3	24.3	24.3
Maybe	337	41.9	41.9	66.2
No	272	33.8	33.8	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H10-1

Improving User Documentation Will Impact Your Ability To Utilize A Computer System

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	383	47.6	47.6	47.6
Possibly	364	45.2	45.2	92.8
No	58	7.2	7.2	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H11-1

Does Software Have A Bug In It If You Follow The Documentation And It Does Not Work As Described?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	204	25.3	25.3	25.3
No	601	74.7	74.7	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H13-1

Too Many Steps In Software Documentation?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	385	47.8	47.8	47.8
No	420	52.2	52.2	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H14-1

Comfort Level Using A Computer[6]

		Frequency	Percent	Valid Percent	Cumulative Percent
Extremely Comfortable	1	215	37.0	37.0	37.0
	2	75	12.9	12.9	49.9
	3	37	6.4	6.4	56.3
	4	20	3.4	3.4	59.7
	5	14	2.4	2.4	62.1
	6	17	2.9	2.9	65.1
	7	22	3.8	3.8	68.8
	8	30	5.2	5.2	74.0
	9	60	10.3	10.3	84.3
Extremely Uncomfortable	10	91	15.7	15.7	100.0
	Total	**581**	**100.0**	**100.0**	

Table 6-H15-1

Do You Fear Having to Re-learn The Use Of A Software Product On Upgrade Or Maintenance Release?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	80	9.9	9.9	9.9
Sometimes	281	34.9	34.9	44.8
No	444	55.2	55.2	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H16-1

[6] Computer use primary function of your work = Yes

Which Would Be More Helpful Than Printed Documentation?

	Frequency	Percent	Valid Percent	Cumulative Percent
Instructor lead in-class lecture with notes	103	12.8	12.8	12.8
Video based lecture with notes, etc	22	2.7	2.7	15.5
Video based lecture without exercises	7	.9	.9	16.4
Computer-based instruction with notes and exercises	125	15.5	15.5	31.9
Computer-based instruction with out notes and exercises	24	3.0	3.0	34.9
After market guides and tutorials	160	19.9	19.9	54.8
Wizards	114	14.2	14.2	68.9
Icons	26	3.2	3.2	72.2
On-line Help	178	22.1	22.1	94.3
None of the above	46	5.7	5.7	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H17-1

What Do You Do When You Encounter a Problem With Software?

	Frequency	Percent	Valid Percent	Cumulative Percent
Pick up printed User Documentation	244	30.3	30.3	**30.3**
Utilize on-line Help	299	37.1	37.1	**67.5**
Call a friend	174	21.6	21.6	**89.1**
Call the software vendor	71	8.8	8.8	**97.9**
None of the above	17	2.1	2.1	**100.0**
Total	**805**	**100.0**	**100.0**	

Table 6-H18-1

Removal Of Which Documentation Product Would Not Hinder Productivity

	Frequency	Percent	Valid Percent	Cumulative Percent
Icons	153	19.0	19.0	19.0
On-line Help	119	14.8	14.8	33.8
Printed User's Manuals	161	20.0	20.0	53.8
Wizards	174	21.6	21.6	75.4
Removal of any	198	24.6	24.6	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H18-2

Removal Of Which Documentation Product Would Not Hinder Productivity

	Observed N	Expected N	Residual
Icons	153	161.0	-8.0
On-line Help	119	161.0	-42.0
Printed User's Manuals	161	161.0	.0
Wizards	174	161.0	13.0
Removal of any	198	161.0	37.0
Total	**805**		

Table 6-H18-3

Test Statistics[7]

	Removal Of Which Documentation Product Would Not Hinder Productivity
Chi-Square	20.907
df	4
Asymp. Sig.	.000

Table 6-H19-1

Comfort Level Using A Computer For Respondents Over 50 Years Of Age[8]

	Frequency	Percent	Valid Percent	Cumulative Percent
1	31	19.3	19.3	19.3
2	28	17.4	17.4	36.6
3	14	8.7	8.7	45.3
4	11	6.8	6.8	52.2
5	14	8.7	8.7	60.9
6	8	5.0	5.0	65.8
7	8	5.0	5.0	70.8
8	10	6.2	6.2	77.0
9	14	8.7	8.7	85.7
10	23	14.3	14.3	100.0
Total	**161**	**100.0**	**100.0**	

[7] Note: 0 cells (0%) have expected frequencies less than 6. The minimum expected cell frequency is 161.0

[8] With 1 representing Extremely Comfortable to 10 representing Extremely Uncomfortable

Graph 6-H19-1

Distribution Of Comfort Level Using A Computer
For Respondents Over 50 Years Of Age[9]

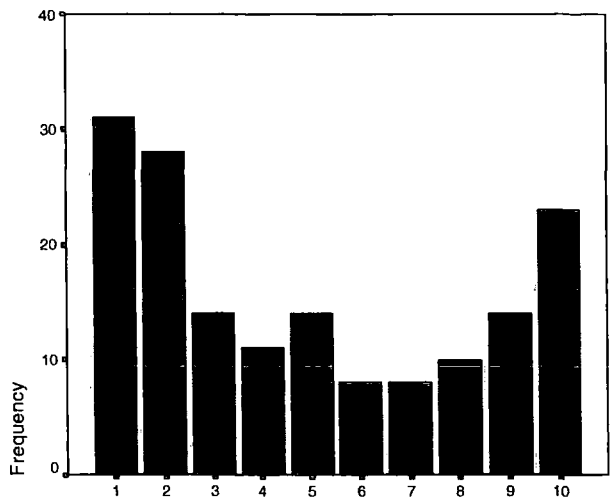


Table 6-H19-2

Distribution Of Comfort Level Using A Computer
For Respondents Over 50 Years Of Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Modified Response	Comfortable	98	60.9	60.9	60.9
	Uncomfortable	63	39.1	39.1	100.0
	Total	161	100.0	100.0	

Table 6-H19-3

Documentation Easy To Read? [10]

[9] With 1 representing Extremely Comfortable to 10 representing Extremely Uncomfortable

[10] With 1 representing Extremely Difficult to 10 representing Extremely Easy

	Frequency	Percent	Valid Percent	Cumulative Percent
1	3	1.9	1.9	1.9
2	10	6.2	6.2	8.1
3	26	16.1	16.1	24.2
4	24	14.9	14.9	39.1
5	33	20.5	20.5	59.6
6	7	4.3	4.3	64.0
7	13	8.1	8.1	72.0
8	24	14.9	14.9	87.0
9	18	11.2	11.2	98.1
10	3	1.9	1.9	100.0
Total	**161**	**100.0**	**100.0**	

Graph 6-H19-2

Documentation Easy To Read? [11]

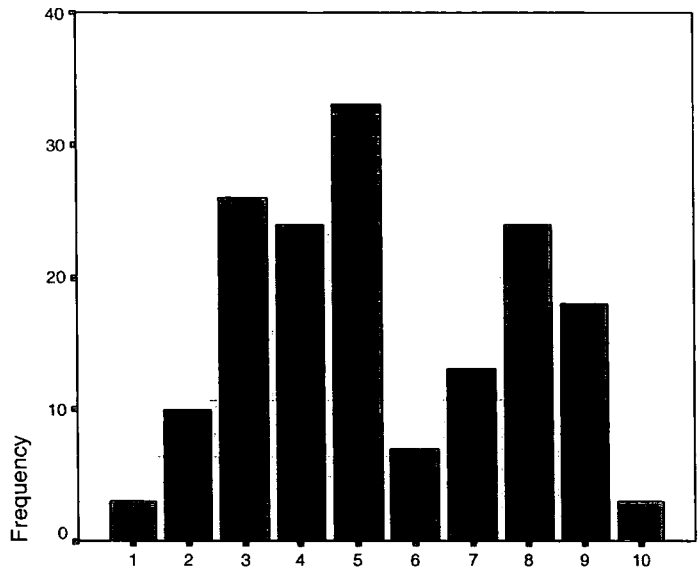


Table 6-H19-4

Documentation Easy To Read?

[11] With 1 representing Extremely Difficult to 10 representing Extremely Easy

		Frequency	Percent	Valid Percent	Cumulative Percent
Modified Response	Difficult	96	59.6	59.6	59.6
	Easy	65	40.4	40.4	100.0
	Total	**161**	**100.0**	**100.0**	

Table 6-H20-1

Distribution Of Comfort Level Using A Computer For Respondents Between 10 And 35 Years Of Age[12]

	Frequency	Percent	Valid Percent	Cumulative Percent
1	159	37.8	37.8	37.8
2	52	12.4	12.4	50.1
3	25	5.9	5.9	56.1
4	15	3.6	3.6	59.6
5	9	2.1	2.1	61.8
6	14	3.3	3.3	65.1
7	22	5.2	5.2	70.3
8	23	5.5	5.5	75.8
9	48	11.4	11.4	87.2
10	54	12.8	12.8	100.0
Total	**421**	**100.0**	**100.0**	

[12] With 1 representing Extremely Comfortable to 10 representing Extremely Uncomfortable

Graph 6-H20-1

Distribution Of Comfort Level Using A Computer
For Respondents Between 10 And 35 Years Of Age[13]

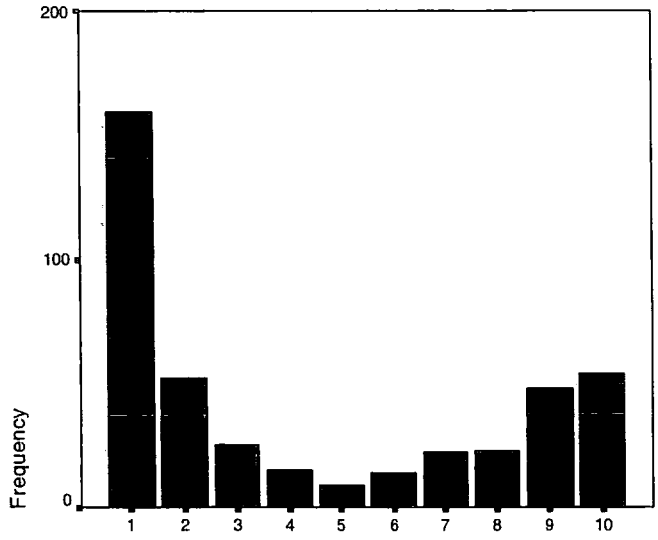


Table 6-H20-2

Distribution Of Comfort Level Using A Computer
For Respondents Over 50 Years Of Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Modified Response	**Difficult**	144	34.2	34.2	34.2
	Easy	277	65.8	65.8	100.0
	Total	**421**	**100.0**	**100.0**	

[13] With 1 representing Extremely Comfortable to 10 representing Extremely Uncomfortable

Table 6-H20-3

Documentation Easy To Read? [14]

	Frequency	Percent	Valid Percent	Cumulative Percent
1	4	1.0	1.0	1.0
2	3	.7	.7	1.7
3	43	10.2	10.2	11.9
4	34	8.1	8.1	20.0
5	60	14.3	14.3	34.2
6	52	12.4	12.4	46.6
7	63	15.0	15.0	61.5
8	82	19.5	19.5	81.0
9	55	13.1	13.1	94.1
10	25	5.9	5.9	100.0
Total	**421**	**100.0**	**100.0**	

Graph 6-H20-2

Documentation Easy To Read?

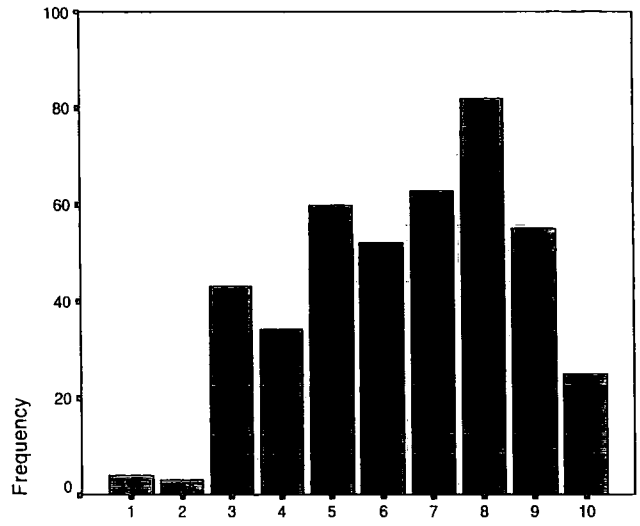


Table 6-H20-4

[14] With 1 representing Extremely Difficult to 10 representing Extremely Easy

Documentation Easy To Read?

		Frequency	Percent	Valid Percent	Cumulative Percent
Modified Response	Difficult	260	61.8	61.8	61.8
	Easy	161	38.2	38.2	100.0
	Total	**421**	**100.0**	**100.0**	

Table 6-H21-1

Difficulty Using Automated Teller Machines

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	8	1.0	1.0	1.0
Sometimes	48	6.0	6.0	7.0
No	749	93.0	93.0	100.0
Total	**805**	**100.0**	**100.0**	

Table 6-H21-2

Age Range * Difficulty Using Automated Teller Machines Crosstabulation

		Difficulty Using Automated Teller Machines			Total
		Yes	Sometimes	No	
Age Range	11 to 15		1	8	9
	16 to 20		5	71	76
	21 to 25		8	92	100
	26 to 30	1	6	130	137
	31 to 35		5	94	99
	36 to 40	2	3	72	77
	41 to 45		3	69	72
	46 to 50		7	67	74
	51 to 55	2	4	69	75
	56 to 60	2	1	23	26
	61 to 65		4	22	26
	66 to 70		1	14	15
	71 to 75			12	12
	76 to 80			6	6
	Over 90	1			1
Total		8	48	749	805

Table 6-H22-1

Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	322	40.0	40.0	40.0
Sometimes	403	50.1	50.1	90.1
No	80	9.9	9.9	100.0
Total	805	100.0	100.0	

Table 6-H22-2

Native Language * Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals Crosstabulation

		Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals			Total
		Yes	Sometimes	No	
Native Language	English (U.S.)	228	274	41	543
	English (U.K.)	51	56	15	122
	French	5	5		10
	German	2	6	2	10
	Spanish	9	8	2	19
	Italian	2	1	1	4
	Greek		1		1
	Portuguese	3	1	1	5
	Russian	1		1	2
	Cantonese	2	1	1	4
	Mandarin	1	4	4	9
	Any African Language	1	2		3
	Any Arabic		2	1	3
	Any Indian Subcontinent	2	5	6	13
	Not Mentioned	15	37	5	57
Total		322	403	80	805

Table 6-H22-3

Native Language * Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals Crosstabulation

		Would American Idiomatic Phrases Hinder The Ability Of Non-Native Speaking American English Individuals			Total
		Yes	Sometimes	No	
Native Language	English (U.K.)	51	56	15	122
	French	5	5		10
	German	2	6	2	10
	Spanish	9	8	2	19
	Italian	2	1	1	4
	Greek		1		1
	Portuguese	3	1	1	5
	Russian	1		1	2
	Cantonese	2	1	1	4
	Mandarin	1	4	4	9
	Any African Language	1	2		3
	Any Arabic		2	1	3
	Any Indian Subcontinent	2	5	6	13
	Not Mentioned	15	37	5	57
Total		94	129	39	262

Table 6-H23-1

Sex * Do You Find Software Documentation Easy to Comprehend? Crosstabulation

		Do You Find Software Documentation Easy to Comprehend?				Total
		Yes	Sometimes	Not Often	No	
Sex	Male	88	338	118	11	**555**
	Female	15	162	64	9	**250**
Total		**103**	**500**	**182**	**20**	**805**

Table 6-H23-2

Chi-Square Tests[15]

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.759	3	.001
Likelihood Ratio	18.556	3	.000
Linear-by-Linear Association	12.119	1	.000
N of Valid Cases	805		

Table 6-H23-3

Chi-Square Test Summary Table

	Yes	No
Male	426	129
Female	177	73

[15] Note: 0 cells (0%) have expected count less than 5. The minimum expected count is 6.21

Table 6-H23-4

Sex * Does Gender Specific Terminology Affect Your Ability To Use A Software Product? Crosstabulation

		Does Gender Specific Terminology Affect Your Ability To Use A Software Product?			Total
		Yes	Sometimes	No	
Sex	Male	31	52	472	555
	Female	13	45	192	250
Total		44	97	664	805

Table 6-H23-5

Mutli-Variable Crosstabulation

	Sex					
	Male			Female		
	Does gender specific terminology affect your ability to use a software product?			Does gender specific terminology affect your ability to use a software product?		
	Yes	Sometimes	No	Yes	Sometimes	No
	Age Range	Age Range	Age Range	Age Range	Age Range	Age Range
	Count	Count	Count	Count	Count	Count
11 to 15		3	3		1	2
16 to 20	2	8	43	1	10	12
21 to 25	6	6	45	1	9	33
26 to 30	7	5	83	4	7	31
31 to 35	3	8	64	1	3	20
36 to 40	4	4	40	1	4	24
41 to 45	1	3	44	2	2	20
46 to 50	3	4	48		2	17
51 to 55	2	5	47	2	3	16
56 to 60	1	1	19		1	4
61 to 65		2	17		1	6
66 to 70	2	1	8			4
71 to 75		2	6		1	3
76 to 80			5		1	
Over 90				1		

Table 6-H24-1

Impact Of Goal Oriented Documentation Impact On Productivity

		Frequency	Percent	Valid Percent	Cumulative Percent
Response[16]	1	30	3.7	3.7	3.7
	2	37	4.6	4.6	8.3
	3	50	6.2	6.2	14.5
	4	54	6.7	6.7	21.2
	5	97	12.0	12.0	33.3
	6	82	10.2	10.2	43.5
	7	101	12.5	12.5	56.0
	8	163	20.2	20.2	76.3
	9	106	13.2	13.2	89.4
	10	85	10.6	10.6	100.0
	Total	**805**	**100.0**	**100.0**	

Table 6-H24-2

Impact Of Goal Oriented Documentation Impact On Productivity

	Yes	No
Frequency	536	269
Proportion	66.58%	33.42%

Table 6-H24-3

Would "Recipe-Type" Documentation Improve Productivity?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	168	20.9	20.9	20.9
Maybe	543	67.5	67.5	88.3
No	94	11.7	11.7	100.0
Total	**805**	**100.0**	**100.0**	

[16] With 1 representing No Impact to 10 representing High Impact

Table 6-H25-1

Difficulty Of Documentation With Computer Games

	Frequency	Percent	Valid Percent	Cumulative Percent
I do not use computer games	142	17.6	17.6	17.6
Just as difficult as other computer documentation	139	17.3	17.3	34.9
Not as difficult	111	13.8	13.8	48.7
Somewhat easier	141	17.5	17.5	66.2
Much easier	80	9.9	9.9	76.1
Don't need	192	23.9	23.9	100.0
Total		**100.0**	**100.0**	

Appendix 4

SURVEY QUESTIONNAIRE

Survey Invitation

Presented below is a copy of the original invitation that was sent electronically to 300,000 email addresses. These email addresses were purchased from an international email marketing company.

> *"I am presently completing a PhD in Computer Science at the University of Durham in England. My research topic deals with the effectiveness of end-user documentation. As part of the PhD, I am conducting a survey of end-users worldwide. It would be greatly appreciated if any one who reads this could take the survey. It is located at:*
>
> *http://www.phdresearch.org/survey/survey1.cgi*
>
> *Thank you. The more people who take the survey the more accurate the results will be."*

What follows is a copy of the survey questions.

Research Survey Questions

1) What is your gender?
   a) Male
   b) Female

2) In which geographical area do your currently reside?
   a) North America
   b) Central America
   c) South America
   d) Europe
   e) Asia
   f) Africa
   g) Australia / New Zealand
   h) South Pacific Islands

3) What age group are you in?
   a) Under 10
   b) 11 to 15
   c) 16 to 20
   d) 21 to 25
   e) 26 to 30
   f) 31 to 35
   g) 36 to 40
   h) 41 to 45
   i) 46 to 50
   j) 51 to 55
   k) 56 to 60
   l) 61 to 65
   m) 66 to 70
   n) 71 to 75
   o) 76 to 80

p) 81 to 85

q) 86 to 90

r) Over 90

4) What educational level have you obtained?

a) Primary school (Elementary School through Junior High School)

b) Some Secondary School, but did not complete

c) Presently a Secondary School Student

d) Secondary school graduate (High School graduate in the U.S.A. or GCSE in the United Kingdom and countries that follow the British system of education)

e) Started College or University, but dropped out.

f) Some College or University education (for the U.S.A., mark this box if you have an Associate's Degree , and for the United Kingdom, or countries that follow the British system of education, mark this box if you have an "A" Level Certificate)

g) Presently a University/College student

h) Completed most University/College requirements, but did not complete undergraduate degree

i) Undergraduate Degree (Bachelor of Arts, Bachelor of Science, Bachelor of Music, etc --- For countries that grant professional degrees, such as Law, Medicine, Dentistry, Pharmacy, Veterinary, etc., at the Bachelor's degree level, please do not mark this box, but mark the Professional Degree box below)

j) Some graduate or professional degree education, but did not complete degree requirements

k) Presently a graduate/professional student

l) Master's Degree

m) Professional Degree (Law, Medicine, Dentistry, Veterinary, Pharmacy, etc)

n) Quasi-Academic/Professional Degree (Doctor of Education, Doctor of Music, Doctor of Psychology, Doctor of Business or Public Administration, etc)

o) Academic Doctor's degree (Doctor of Philosophy, Doctor of Arts, Doctor of Science, etc)

5) In which of the following disciplines do you hold an Undergraduate degree or higher?

a) I do not have an Undergraduate or higher degree
b) The Social Sciences (Anthropology, Social Work, etc)
c) The Psychological Sciences
d) The Letters (English, Languages, History, Political Science, etc.)
e) Law, Business or Public Administration
f) The Arts (Music, Art, etc)
g) Engineering (Electrical, Mechanical, Chemical, etc)
h) Natural Science (Chemistry, Biology, Physics, Mathematics)
i) Medical Sciences (Medicine, Dentistry, Pharmacy, Veterinary, Nursing, etc)
j) The Computer Sciences (Information Systems, Management Information Systems, Computer Science/ Engineering)

6) What is your native language?

a) English (U.S.)
b) English (U.K.)
c) French
d) German
e) Spanish
f) Italian
g) Greek
h) Portuguese
i) Russian
j) Japanese
k) Korean
l) Cantonese
m) Mandarin
n) Any African language
o) Any Arabic language
p) Any Indian Subcontinent language
q) Other

7) On a scale of 1, representing Extremely Comfortable, to 10, representing Extremely Uncomfortable, how to you rate yourself in using a computer?

8) On a scale of 1, representing No Impact, to 10, representing Extreme Impact, how would you rate the effect that software User Documentation has on your ability to properly utilize a computer?

9) If User Documentation were to be improved, do you believe that this would have an impact on your ability to utilize a computer?
   a) Yes
   b) Maybe
   c) No

10) Do you have any difficulty in using an Automated Teller Machine?
   a) Yes
   b) Sometimes
   c) No

11) Where do you use a computer?
   a) At home
   b) At work
   c) At school
   d) At home and school
   e) At home and work
   f) At work and school
   g) At home, work, and school

12) Do commercial software vendors regularly supply User Documentation in your native language?
   a) Yes
   b) No

13) Is the use of a computer, and software packages, a primary function of your work?

a) Yes

b) No

14) Do you use the computer to play games?

a) Frequently

b) Sometimes

c) Not often

d) Never

15) Which of the following best describes your experiences with documentation supplied with computer games?

a) I do not use computer games

b) Just as difficult to understand and use as other computer documentation

c) Not as difficult to understand and use as other computer documentation

d) Somewhat easier to understand and use

e) Much easier to understand and use

f) Don't need to use the documentation with computer games

16) When you first utilize a software package, what are you most likely to do?

a) Read all of the accompanying User Documentation and Tutorials

b) Read some of the accompanying User Documentation and Tutorials

c) Read all of the accompanying User Documentation

d) Read all of the Tutorials

e) Read some of the accompanying User Documentation

f) Read some of the Tutorials

g) Read nothing, just start using the software

17) Do you find that the User Documentation provided with software applications is easy to comprehend?

a) Yes

b) Sometimes

c) Not often

d) No

18) Have you ever utilized an after-market software user documentation product (such as books, videotapes, etc) because the vendor supplied software user documentation was incomprehensible?

a) Yes

b) No

19) When you attempt to follow the instructions in a software package's User Documentation and you do not achieve the desired results, do you then believe that the software has a "bug" in it?

a) Yes

b) No

20) If you attempt to follow the instructions in software package's User Documentation and you do not achieve the desired results, and you then believe that the software has a "bug" in it, do you report this "bug" to the software vendor, developer, or in-house Help Desk?

a) Yes

b) No

21) When you report a software "bug" to a Help Desk, either in-house or vendor, what is the average amount of time that you have had to wait until you receive a response, or proposed solution, to your reported "bug"?

a) I do not report software "bugs"

b) Less than 30 minutes

c) Less than 1 hour

d) Less than 2 hours

e) Less than 4 hours

f) Less than 6 hours

g) Less than 8 hours

h) Greater than 1 business day

22) On a scale of 1, representing No Impact, to 10, representing a High Impact, how would you perceive the impact that specific Goal/Objective Oriented, step-by-step, User Documentation would have on your productivity and satisfaction with a software product?

23) If software were to be developed with a more intuitive User Interface, would this improve your productivity with the software product?

a) Yes

b) Maybe

c) No

24) On a scale of 1, representing Extremely Satisfied, to 10, representing Extremely Dissatisfied, how would you consider your overall experiences with vendor or developer supplied User Documentation?

25) If software User Documentation where to have more examples, in picture format, of expected results, would this improve your ability to utilize the software product?

a) Yes

b) Maybe

c) No

26) Do you utilize software documentation in your native language?

a) Yes

b) No

27) If your native language is not American English, do you believe that the use of American idiomatic phrases in vendor-supplied software documentation hinders your ability to properly comprehend and utilize the software?

a) Yes

b) Sometimes

c) No

28) On a scale of 1, representing that you can always find the solution to your software problem in the vendor supplied documentation, to 10, representing that you hardly ever find the solution to your software problem in the vendor supplied documentation, how would you rate your experience with vendor supplied software documentation?

29) On a scale of 1, representing that User Documentation has an extremely high impact on your overall satisfaction with a software product, to 10, representing that User Documentation has almost no effect on your overall satisfaction with a software product, how does User Documentation impact your overall satisfaction with a software product?

30) On a scale of 1, representing extremely difficult, to 10, representing trivial, how easy do you find software documentation to read and comprehend?

31) Mark the selection that best describes your involvement in the development, maintenance, or sales of software products.

a) Develop or maintain software applications

b) Write software documentation

c) Provide Help Desk support functions

d) Sell software or provide any sales support function (either pre-sales, post sales)

e) Management of any computer function

f) None of the above

32) If a software product documentation suite contains Icons, On-line Help, Menus, printed User's Manuals, and Wizards, which of the preceding, if removed from the product, would not hinder your productivity with the product.

a) Icons

b) On-line Help

c) Menus

d) Printed User's Manuals

e) Wizards

f) Removal of any would hinder my productivity

33) On a scale of 1, representing a Pure After Thought, to 10, representing Fully Planned and Organized, how would you rate the software industry on the overall design and implementation of end-user documentation?

34) Which of the following do you find to be more helpful than vendor supplied printed User Manuals for comprehending the capabilities of a software product? (Select one only)

a) Instructor lead in-class lecture with notes and exercises

b) Video-based lecture, with exercises and notes

c) Video-based lecture without exercises

d) Computer-based instruction with exercises and notes

e) Computer-based instruction without exercises

f) After-market guides and tutorials

g) Wizards

h) Icons

i) On-line Help

j) None of the above

35) When you do utilize a software user documentation product, which are you more likely to utilize?

a) On-line Help functions

b) Icons

c) Wizards

d) Vendor supplied hardcopy documentation

e) Internet-based documentation

f) After market documentation

g) None of the above

36) If you encounter a problem with a software package, either commercially produced or in-house developed, which are you more likely to do?

a) Pick up the software's printed User's Documentation to independently solve the problem
b) Utilize the software's On-line "Help" Function
c) Call a friend or an associate to help "walk" you through the problem
d) Call the vendor or, if in house, the Information Technology, Help Desk
e) None of the above

37) On a scale of 1, representing Totally Useless, to 10, representing Extremely Helpful, how would you rate the documentation that is provided by the software manufacturer with the software packages that you utilize?

38) If documentation for software product where to be developed in a "recipe-type" format, would this improve your productivity with the software product?

a) Yes
b) Maybe
c) No

39) On a scale of 1, representing Always Relevant, to 10, representing Hardly Never Relevant, how would you rate your overall experience with examples that are provided within software User Documentation with the tasks that you desire to perform?

40) Does the use of gender specific terminology within a software product's User Documentation have an effect on your ability to properly utilize the software package?

a) Yes
b) Sometimes
c) No

41) On a scale of 1, representing Totally Confident, to 10, representing Totally Unconfident, how confident are you in the fact that you possess the most current, or most recent, edition of the User Documentation for all of the software products, either in-house developed or purchased off the shelf, which you utilize on a regular basis?

42) When a software vendor announces a software upgrade or maintenance release, do you fear having to re-learn the use of the software product?

a) Yes
b) Sometimes
c) No

43) Does software documentation, in your opinion, generally have too many steps to easily remember how to accomplish a given task without frequently looking back at the documentation?

a) Yes
b) No

44) Do you believe that software manufacturers purposely provide inferior documentation so that they can create a market for additional products, such as books, videotapes, and other training materials?

a) Yes
b) Maybe
c) No

45) Do menu-based software packages help, or hinder, your productivity?

a) Help
b) Hinder

46) On menu-based software packages, do you generally find that there are too many options to remember for each menu item, and as such, you have to look at each menu item to determine if it contains the option that you wish to use?

a) Yes

b) No

47) Have you ever started to use end-user software documentation for a product and then find out that the documentation is not for the same version of the software that you are using?

a) Yes

b) No

48) On a scale of 1, representing Very Frequently, to 10, representing Hardly Ever, how would you rate your use of Wizards in obtaining a specific objective within a software product?

49) As a tool for allowing a user to learn how to use a software product without any additional User Documentation, how would you rate, on a scale of 1, representing Very Helpful, to 10, representing Not Very Helpful, the use of icons?

50) Do you consider a software package's user interface as part of the user documentation?

a) Yes

b) No

Appendix 5

SURVEY COMMENTS

During the course of the research for this thesis, an electronic survey methodology was utilized. Although this methodology did not allow for "free form" responses, several individuals emailed the researcher with their comments, views, and criticisms. Contained within this appendix are those comments received, in no particular order, with the sender's email address and name removed to preserve anonymity. Spelling, grammar, and punctuation are exactly as the author of the email presented them.

Individuals who provided comments ranged from professional software developers, to a Fire Chief in California, to an elderly lady, to professional researchers, and many others too numerous to mention.

Following are the comments:

> *'I filled out one of your surveys. You may also want some free-answer info from me - specifically, I use unix in my work and I hate unix because it is so non-intuitive and documentation is so obtuse once you even know the command you need to use - if you don't know the command you are pretty much stuck because there's no simple way to get a list of commands. What's more, unix is non-standard- it's different on a sun from an sgi from an ibm from linux for pc, etc and I find plenty of times when scripts work on one machine but not on another, or in bash but not csh etc. Where I work at National Weather Service, the computer help does not instead say National Centers for Environmental Prediction and note this is U.S. (since you are probably looking at this issue internationally) provide users with a .cshrc file to start with or any pointers to useful software or any of the relevent environment variables, and they "maintain" software which they don't have environments set up to even be able to use it, you have to talk with someone who uses that package to find out how to set things up. It's quite horrific. And from what I've heard about university faculty situations, they often have even less help, basically have to be their own system managers.*
>
> *While unix is powerful, it maximizes the opportunities for human error and impedes ability to find those errors or find out how to correct them. It's a huge time sink and talented scientists are wasting huge amounts of time dealing with low-level unix*

functions when they could be doing higher level programming and getting scientific results if the there were a decent user interface."

"hello:
i do research in the effects of memory on decisions. one needs a lot of discipline to work withing specific standards and time frames. i have studied the effects of fear versus confidence in these areas, and feel that the software community have made life very dificult for those who have to make long range financial decisions.
cheers!"

"Dear. P.J. Wilkinson
I am currently a freshman in college and the following mistakes hindered my ability to accurately answer your survey:
1. You used large words that seem to be there only to confuse the readers.
2. In question #39 you used a double negative, I do not know very many of the grammar rules in U.K. English language.
Question 39 : "to 10, representing Hardly Never Relevant".
In the United States it would be "Hardly Ever"
Some American may think less of you due to the differences in the English language (U.K. compared to U.S.), may need to consider creating a survey that is easier to comprehend. Please reply and tell me if a double negative is ok in the U.K.
Sincerely"

"Dear Sir/Madam: I don't know if this would be helpful, but I'd like to tell you a "pet peeve" I have in the instruction --either in the classroom or in user documentation. I would like to see more of a "total view" given.
One example of this would be to include a chart listing of all the menu items and all the options beneath them, so I could turn to one page and see all my options. This

would then encompass the right brain which sees the whole picture and then the left brain which is good at analaysis and detail.
Good luck with your thesis.
Regards,"

"Mr. Wilkinson,
You might explain a little bit more about the survey you are undertaking and provide a little more assurance that your cgi script isn't going to launch some devilish harm to the recipient's computer. In this day of global virus attacks, you can appreciate my reluctance to simply click on the link to your survey script. If you have a web page that provides more information, it would help to allay concerns. I, as many others, do not follow links to .exe., com or .cgi destinations for shear preservation.
I might be otherwise inclined with a little more information.
Best regards,"

"Good luck. I completed the questionnaire. I live on Wilkinson St."

"I just filled in your survey on software documentation, and was rather dismayed to find out that you gave no opportunity for users to submit comments.
I found a number of concepts and questions in the survey problematic, and overall the perspective rather narrow. My reading of the survey suggests that you fail to consider the impact of good (or bad) software design, separate from user interface and documentation, as an essential factor in ease of use, and that you leave little room for the influence of the user's knowledge of computers and software in general.
It wasn't clear to me if your definition of "end-user software documentation" includes literature of a more general nature including magazine articles, resources on the Internet, or books providing a theoretical background to a particular area, to name a few which have been important for my ability to use software.
Some points relating to specific questions

6) what about other varieties of English (Indian or Australian, for instance)?
21) different software authors vary radically in their responsiveness. I have personal experience with both immediate response and complete lack of support. I find taking an average rather meaningless.
23) it isn't clear what is meant by an 'intuitive user interface'. perhaps it would be more useful to ask if one finds user interfaces counter-intuitive... however, I find this far to broad a question to answer generally
24) again, I am acquainted with examples of exceptionally good, and exceptionally bad documentation
25) surely this is only appropriate to software with a graphical user interface?
40) while I find the use of sexist language unacceptable in all contexts, I fail to see how it could effect my ability to use a program
45) whether "menu based" software helps or hinders really depends on whether this type of user interface is appropriate to problem at hand and the design of the software.
cheers,"

"How about doing some research on spam mail and how users that never sign up for anything get onto these mailing lists?
Have a nice day."

"Whilst I understand what you're doing is probably for a very good cause, I'd like to ask where you got my email address from? I've put up with unsolicited mail from a number of places in the past, but the volume has increased dramatically over the last few weeks, and quite frankly, I'm sick of it!

Anyway, nothing personal, but if you could tell me where you got my address from, I'd appreciate it, and I'll forgive you for the unsolicited mail!:-)"

"PJ.

I have done my part and have already process the survey
Have a nice day"

"It was interesting, I had to rething some questions ;-)
My comments:
pos. 10: I do not know what it is "automated teller machine" so I marked it as 'no'
pos. 50: after all thinking during survey I marked 'yes'. Without it I would have never think like this.
Best Regards"

"Please do not involve yourself in software documentation. Your questionaire was clumsy and high handed and did not take into consideration the diversity of the software documentation available. Some vendors are very good, others are not. Most IT professionals obtain help via the web, not just through the vendors. Your survey took no consideration of this area
Good luck with your research
Regards"

"Hi P.J.,
I appriciate the sincerity and veracirty of your mail. It's rare to find ,on net, purposeful multicasted mail. I think for the first time I considered a anyonymous mail and I was delighted to find that my decision was worthwhile as the request was true. I wish you get the desired result out of this survey."

"Just few thoughts, I think that the information is basically there, it just needs a bit of re-arranging. The following are some pointers

Question 36 contains a confusing typo: it should say the "software's printed..." rather than "software's printer "

"Hardly Ever" is confusing, Never would be a better choice
Use shorter sentences, some of the sentences are too long and loose their meaning after 10 words.
Ask the question, then provide the scale
There is a distinct sense of confusion and incoherence in the general feel of the questionnaire. I found it difficult to get involved, it sometimes reads like a software manual"

"Sorry, I'd like to help, but I don't even know what an end-user is. Retired academic from the liberal arts."

"As a professional software developer, and user, I am very interested in the effects of user documentation. I am very frustrated by an experience that I am currently having in the installation and configuration of WinGate on a friends computer. Wingate provides what I would consider a fair installation guide, but rotten trouble shooting information.
I do "custom" programming for our clients. Our base product is so configurable and supports scripting so that very little need for custom ehhancements exists. Still it keeps four full time developers busy (deparment to expand to eight by end of cal.2000).
These custom peices usually are in manufacturing, warehouseing, and product distribution environments. Industrial coding. The UI has to be very simple. If I need to provide more than one page of documentation then I did not design it right.
I recently designed a sales order entry system to be used on hand held computers (Windows CE). We sat down with the sales managers and showed them the system and OS in a one hour session. Each person with unit in hand. We then brought in

some sales people. I spent 10 minutes explaining the OS and the managers trained the use of the application in 20.
ATB"

"The current buzz word around our place is, "Customer Satisfaction". I have been with this company for two years as of 1 July. The previous company (16 years with them) had a good watch phrase. "Do whatever it takes to generate the fewest calls to the help desk."
Empowering the user to be able to solve their own problems, or to be able to avoid problems in the first place, leads to customer satisfaction. It ALL plays a part in this. A good UI, documentation, robust internal procedures (error handling, error correction, error avoidance, etc.), training, and high quality tech support. Drop the ball on any of these fronts and you will lose.
How to tell if you have won. When the customer picks up the phone and orders more work (products or services), then you will know. Trapping your
customers is cheating. It cheats you and the customer.
I love little watch phrases. They help keep your principles in front of you. I have been writing software for a living since September of 1972. Not too bad for an NDP, huh?
ATB"

"Hi there-
Shari asked me to do your survey (I'm assuming its yours as the your name is the same as the friend she asked me to help out by doing it). I also noticed that your survey is in American English rather than the Queen's English which matches up (but doesn't explain) the Pacbell.net e-mail address.
In any case, going on that assumption - it would appear that you may have overlooked a few considerations:

Firstly, in your classification questions, you inquire about what degree and in what area someone has achieved. Technically, Journalism/Mass Communication can be considered a Liberal Arts, but not a Fine Arts-class major. I put down "letters."

I'm a graphic artist and I make my living using various programs related to desk-top publishing. I have found the documentation to generally poorly written - as if it were written by software engineers for software engineers. The online help is spotty as well. Invariably, there isn't a reference to the function I want to perform. Wizards are no better than pre-fab templates and are only usefull for producing cookie-cutter pieces - making changes requires that you know the program in the first place. The point of this is that while limiting the available answers makes it easy to quatify data, you're not getting the entire picture.

Additionally, questions 22, 29 and 49(?) are poorly written - they're like reading software documentation. ;->

Lastly, the questions regarding whether I consider the program to be "buggy" if I follow the instructions and it doesn't work properly is too limiting - the next question assumes that I do. This pre-supposes that we're talking about installing the program. If we are talking about the day-to-day operation, then its just poorly written docs. If we are dealing with the former, I consider the documentation to be defective or I look for software conflicts. If its the latter, its the documentation that is at fault. For installation problems, I turn to the tech support. For procedural/process problems (such as putting in page numbers), I pull out an after-market reference book.

Hopefully, your research will bear fruit and if we're lucky the developers may wish to reconsider the value of their electronic documentation, paper docs, and having somebody competent write the damn things.

I did check out the statistics for you survey, and I'm going to forward the URL to a friend of mine in Brazil. She'll be the first South American to contribute. =o)

Cheers,"

"your survey is too long... I started to answer it but gave up around question 98574."

And, lastly, the one comment that requested not to be anonymous:

'Paul,

Thank you for asking if you could use my company's comments. In the event they are of use to you, please go ahead. The only caveat is that we would like to receive credit for the comments.

With that said, the comments are yours.

You can find us on the web.
Don Oderkirk, PE

Dear Mr. Wilkenson,

Just finished your survey. My it took some time, you are very thorough. For your information let me give you some input regarding the ease of taking the survey.

First, let me give you information on my company (www.bpi-pllc.com). One of our services is to produce what we call "Process Operating Guides". They are the fundamental building block of training programs for factory operators and are used to optimize the efficiency and consistency of factory operations. They follow the ISO format for manufacturing operations. Hence, we have some experience in concise, understandable, and brief communications language used to many persons performing the same task such that they will perform the tasks in a definably repeatable manner since they must understand the meaning in a similar manner regardless of their background or education level.

So, the point to my email for you, is that I wish to give some constructive criticism. If in in setting up your survey it would be much faster for the user of your survey to

complete the survey you could improve the number of responses. If you put an indicator of "good", "bad", "often", "never", etc at the beginning and end of the selection number list it will be ever so much easier to take the survey.

It took a significant amount of time to read each question and then re-read to determine which end of the selection list my answer was at for each question.

Also, there did not appear to be consistency from one question to the next regarding a common side for the "good" end of the selection list. Albeit that did not apply to all questions since some were not of the "good" versus "bad" variety, but if you try a slightly different layout for your questions it may allow you to take some of the "wordy-ness" out of your questions and streamline the taking of the survey for the user, and hence your response may improve.

GOOD	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
BAD										
OFTEN	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
NEVER										
MANY	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
FEW										

Get the point?

I give you these comments in good faith because about half way through your survey I grew very weary of re-reading the question to see which end of the selection list my opinion was at. So weary that I almost said the heck with it. But obviously I did not.

Best of Luck from an American Businessman.
Don Oderkirk, PE
Vice President Operations"

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