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Design and evaluation of a PDF print estimating system

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DESIGN AND EVALUATION OF A PDF PRINT ESTIMATING SYSTEM

A Dissertation

Submitted

in Partial Fulfillment

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Doctoral of Industrial Technology

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August 2003

Dedicated to my parents, my sister, my brother, and my wife
for their support, encouragement, and love

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This study could not have been completed without the support of the following people. From the bottom of my heart, I thank them for their support and help.

Most graduate students are filled with excitement and relief as they work on this page. Writing this page represents a final milestone in the research process. However, I am not so joyful at this important moment because it means I am coming close to the end of the guardianship of my advisor, Dr. Charles D. Johnson. Early on I realized that working with him was a rare opportunity, and I strived to learn as much as possible from him. His understanding is like an iceberg. I see only a portion of it but know it runs deep. When you have an advisor as knowledgeable, gentle, and kind as Dr. Johnson, you know that you will be led down the right path at all times. I am very grateful to him for looking out for me and advising me in my studies during my years at the University of Northern Iowa. He has been an invaluable presence in my life.

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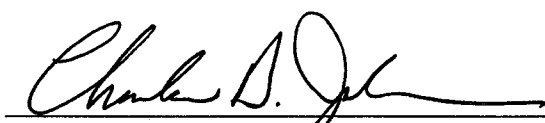

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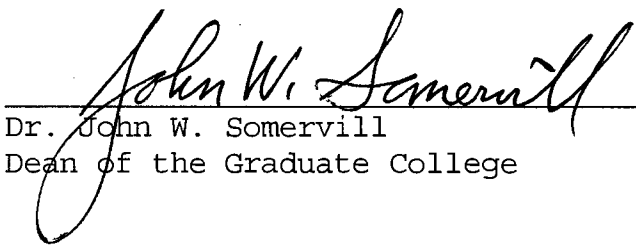

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ABSTRACT

This research consisted of designing and evaluating a portable document format (PDF) print estimating system comparable to commercial systems. Taking into account functionality, reliability, standardization, and integration, the conventional design method (Pressman, 1997) was used to develop the print estimating system. Considering the printer's viewpoint, added features make the system function online and offline and compatible with all common computer platforms. After the system was developed, experts and entry-level users evaluated the system for software usability (Nielsen, 2000; Shneiderman, 1998). A total of 26 experts and 38 entry-level users responded to 14 questions about usability in a personal interview survey. Statistical analysis of survey responses provided evidence that the software is usable for both user groups. This was initially indicated by a mean score above neutral (2.5) for each of the 14 survey items rated by each user group. This result was verified using one-sample *t* tests and independent-samples *t* tests to compare survey items. A one-way repeated-measures ANOVA was used to analyze the differences between item responses. Finally, factor analysis with varimax rotation was used to identify survey response patterns.

CHAPTER 1

INTRODUCTION

Printing and Print Estimating

Printing has been identified as the single most significant technological development in history and has been recognized as the first and the most important communication medium (M. J. Adams & Dolin, 2002). Because of printing, ideas and knowledge can be preserved and distributed for centuries.

The printing industry has a tremendous impact on the economy and is the third largest manufacturing industry in the United States (Larson, 2000). Further, it is predicted to manufacture products worth 1 trillion dollars throughout the world market by 2004 (*Worldwide Printing*, 2000).

Print Estimating

Each print job is a combination of different processes because each printed product has its own design, content, and production method. Determining the cost of an order is obviously complicated, and print firms use a variety of methods to figure a print order (Beach, Shepro, & Russon, 1986; Williams, 2001). Within the entire print production procedure, print estimating is the first and the most important step. Print estimating evaluates the financial

impact of potential orders on a print firm (Ruggles, 1996). In determining the total manufacturing cost, a print estimator deals with assorted possible operations, different material costs, diversified production priorities, and unpredictable print volumes. Urgent deadlines may compound an estimator's concerns. If anything goes wrong in estimating, a company's production and profit will be impacted.

Online Print Estimating

The Internet has changed the print market and has increased competition in the world of printing. Electronic commerce (e-commerce) has created a way for companies to work with customers via the Internet, thus printing transactions occur between countries and continents (Rosen, 2000). The Internet allows print firms to communicate with worldwide customers, provide them with information about their print firms, exchange files and data, and develop marketing strategies (Roth, 1998). Online print estimating opens prices to the public. If the price determined by a company is too low, the company may lose money; if the price is too high, it may lose the order. Therefore, a quick and explicit estimating system that is integrated with e-commerce capability can help a print firm become more compatible and acquire more business.

Computer Print Estimating Systems

Current print estimating systems are only compatible with either IBM PCs or Macintosh computers. Most of them cannot run on both platforms (Ruggles, 1996). Because of the differentiation of computer architectures and operating systems, it is difficult to find an application that is platform independent—one system that can run on different computer platforms.

Present print estimating systems are mainly designed for experts such as estimators. Most of these systems are complicated and difficult to learn. Print estimating websites, the other type of estimating system, have a simplified design but may not provide the user with a precise estimation. These simplified designs are based on general characteristics of the trading environment and do not always have sufficient detail and information to attain a high estimation performance. Another contributing factor to poor estimation performance may be the user. Despite the relative friendliness of the user interface, public online users may lack training or not fully understand some technical system terms. Companies may make a tradeoff between the friendliness of the user interface and estimation performance in order to generate an optimized online trading environment.

Designing a PDF Print Estimating System

System design is a multi-step process in which representations of data and program structure, interface characteristics, and procedural detail are synthesized from information requirements (Pressman, 1997). In this study, a prototype of a print estimating system in the Portable Document Format (PDF) was designed. PDF, the most dominant format in printing, was adopted in this study because it provides a way to estimate through the Internet and functions on the majority of computer platforms.

Design Method

The conventional design method is a software development technique that consists of analysis, design, and testing procedures. It is widely used throughout the software engineering industry (Pressman, 1997). Following are design steps based on the conventional method.

1. Data design. Designing a print estimating system in PDF was a brand new idea, so it was necessary to confirm whether PDF was appropriate for a print estimating system. Released in 2001, PDF 1.5 has calculating, interactive features and supports JavaScript, a cross-computer platform language. These features have generated a tremendous potential for PDF's usage. After the PDF capabilities needed

to construct a print estimating system were confirmed, a data flow diagram was created to direct the development of the estimating system.

2. Architecture design. Based on the data flow diagram, a print estimating template was developed using a spreadsheet application. This template confirmed the correctness of operational flow and mathematical formulas within the system. A PDF print estimating system was developed with the same flow design as the template.

3. Interface design. A number of commercial print estimating systems and estimating worksheets from different print firms were studied and served as the basis for the interface design of the new PDF print estimating system. One of the main concerns of the interface design was assuring consistency with printed worksheets to reduce the effort in transition from manual estimations to the computer system.

4. Procedure design. This step provided links to navigate different modules within the estimating system and created Hot Help, a special feature from PDF that provides user assistance. These features can help final users more efficiently and easily operate the designed system.

When designing software, a specific type of design method is necessary in order to direct the design procedure

and achieve an industrial standard. In this study, the conventional design method fulfilled the needs and provided explicit direction for the development of the print estimating system.

System Evaluation

Following the development of the designed print estimating system, a more comprehensive and objective evaluation was conducted. This evaluation looked at usability, which consisted of system capability, layout and design, learnability, and overall satisfaction of the designed system. Software usability has been widely used in inspecting prototypes and has proven useful to the information industry. Appropriate system design and excellent software usability are two key elements for a successful application (Nielsen, 2000).

Software Usability

Software usability addresses the relationship between applications and users. It is an inspection of the learnability, utility, likeability, effectiveness, flexibility, and operability of the new software (Molich & Nielsen, 1990). Usability inspection typically has been applied to computer systems, software, and websites. It was used in this study to evaluate the designed print estimating

system as well. Usability studies can help determine how easily the software can be learned, how efficiently the software can be operated, how easily the software can be used without relearning, how frequent and serious are user problems and errors, and to what degree user satisfaction is subjective (Shneiderman, 1998). The goal is to create an optimal means for users to accomplish tasks.

Software Usability Evaluation

After the print estimating system was built, a usability evaluation survey was conducted using estimators, production managers and planners, and salespeople from the printing industry as experts and graphic designers, publishers, prepress operators, and students majoring in graphic communications as entry-level users. The survey examined the usability of the designed system and compared the designed system with existing print estimating systems.

Although the designed system potentially would overcome the difficulties in the current trading environment, without an objective final user test of software usability it was not positively known whether it would function well and solve problems. In addition, the usability survey examined the designed system and elicited comments and suggestions for future development.

Statement of the Problem

The problem of this study was to design a PDF print estimating system that has e-commerce and computer platform-independent features and to determine the usability of the system. Further, the designed system was compared with commercial print estimating systems.

Purpose of the Study

The purpose of this study was to design and evaluate a print estimating system that is in a standard industrial document exchange format—PDF. The PDF print estimating system was designed to eliminate problems in printing workflow and simplify print production operations.

This study tested the software capability of the designed PDF print estimating system with final users. Another purpose of this study was to compare the designed print estimating system with commercial print estimating systems in order to determine the strengths and weaknesses of the new system.

Further, the software usability survey within this study determined the satisfaction of different professional levels of users. Users with different backgrounds have different expectations of new software and tend to identify different problems (Nielsen, 2000). People involved with print

estimating may also have different levels of knowledge regarding printing operations and therefore have different expectations and needs.

Statement of Need

This study was needed due to the problems that exist in print estimating. A newly designed print estimating system in PDF could eliminate difficulties in print production and increase integration with current printing workflow.

A Versatile Print Estimating System

As the popularity of the Internet has increased dramatically, e-commerce has been widely adopted in the printing industry. The Internet is a convenient medium for printers and print buyers to communicate and trade (*Vision 21*, 2000). The most important advantage of the Internet is that businesses can run 24 hours a day, seven days a week without geographical boundaries. As Internet service continues expanding and improving, customers will be increasingly more likely to order their print services online. Thus, a print estimating system designed for both online and offline is necessary.

The competition between computer operating systems is unending. Most of the time, print shops have difficulty determining which operating system customers have used to

create their documents. A file that is created in one computer operating system environment may not function well when opened in another system. This scenario makes file exchange difficult and generates many problems in print production; therefore, a document or an application with a standard exchangeable format will offer a solution.

A Workflow Compatible Print Estimating System

PDF workflow is one of the standard workflows in the printing industry, and it is gaining popularity dramatically (M. J. Adams & Dolin, 2002). The newly designed system could eliminate prepress problems and increase operation efficiency because it is compatible with PDF print production workflow. No extra applications are needed to operate the designed system in a PDF workflow environment. As a matter of fact, the estimating system itself is an output application.

A Consistent Output Print Estimating System

One of the advantages of PDF is its capability for consistent output results regardless of the type of printer. PDF documents can provide exactly the same output results regardless of the kind of computer platform or the type of output device (Adobe Systems Incorporated, 1998). This is known as "WYSIWYG," What You See Is What You Get, a desktop publishing byword from an old television show. For print

estimating and print production operation, the ability to print forms such as worksheets, job invoices, and job tickets is necessary. Even though computer print estimating systems are the major applications used in print shops, manual estimation on printed worksheets is still preferred in certain situations. The print estimating system in this study was designed to fulfill different needs, whether they be digital or manual, in print estimating operations.

An Output Files Embedded Print Estimating System

The designed system has a unique function in that it can preserve the output files within the estimation. All types of output files such as QuarkXpress, PageMaker, InDesign, Word, Corel Draw files, and even PDF documents can be embedded. A print shop deals with hundreds or thousands of files every month, so searching for previous output files can be a time-consuming challenge. The designed print estimating system can preserve the estimating records and output files together, so retrieval will be more efficient.

An Easily Learned Print Estimating System

Existing print estimating systems are complicated. Some of them have manuals with hundreds of pages. Some companies must even provide workshops to teach users their systems. A print estimating system that is quick and easy to learn and

use will be beneficial for businesses needing a short turnaround time. The designed system conducts estimating procedures on a PDF worksheet that is in the same flow as print production, so the new system eliminates redundant learning procedures and helps users quickly become accustomed to the system.

A Quick Updating Print Estimating System

The PDF print estimating system is designed with a company profile that includes all the variables for the estimation formula. Variables such as difficulty factors of the operations, budgeting hourly rates, minimum charge rates, machine rates, stock prices, and ink prices are all within the company profile. Users can monitor and modify them with little effort. A quick and easily modifiable print estimating system is useful especially when prices of materials change often.

An Optimal User Interface Print Estimating System

A fundamental of successful software application is strong user satisfaction. A usability evaluation by potential final users is commonly conducted in the early stages of development of computer applications (Shneiderman, 1998). In this study, a usability evaluation was conducted in order to identify optimal user interface. The evaluation

provided feedback from potential users that will be used to improve the designed system.

The purpose of designing a new system was to solve existing problems and provide more features. A print estimating system in PDF can achieve this purpose and has great potential in print production.

Contribution to Knowledge

In this study, a PDF print estimating system with a number of unique features was developed to simplify the production procedure and overcome existing problems in print estimating. Both the designed print estimating system and usability research for this system extended existing knowledge related to print estimating.

Research Questions

This study focused on the design and evaluation of a PDF print estimating system. The following are research questions that were addressed.

1. Does the designed PDF print estimating system perform as specified, providing correct estimates for a wide variety of print orders?

2. Are the capabilities of the PDF print estimating system adequate for expert users as well as entry-level users?

3. What is the level of perceived software usability when comparing expert users to entry-level users?

4. How does the software usability of the designed PDF print estimating system compare with commercial print estimating systems?

5. What suggestions and recommendations do experts and entry-level users have for the designed system?

Limitations

Limitations identify potential weaknesses of a study (Creswell, 1994). The limitations of the designed PDF print estimating system are as follows.

1. The designed PDF print estimating system cannot have features of both file import and file export if it is operated with Acrobat Reader.

2. The designed estimating system was tested and functioned well only with Acrobat 5.0 or Reader 5.0. Some features may not function if the designed estimating system runs on previous versions of Acrobat or Reader.

3. The designed estimating system was only tested in an English environment. It cannot be guaranteed to work well in other languages.

4. Respondents to the questionnaire were in the same geographic region, so this impacts any generalizations.

5. Survey respondents were provided training by the developer of the estimating system and had a limited amount of time to learn the system. Both of these factors potentially influenced the ratings.

Delimitations

Delimitations address how a study can be narrowed in scope (Creswell, 1994). In order to make this research feasible, the following delimitations were used.

1. Different print estimating systems are designed for different size companies. The designed estimating system targets mid-size print firms that estimate offline or online.

2. The designed system is based on the activity-based cost accounting method. This is the most popular method used by digital and traditional print firms. Other approaches or methods are available for print estimating.

3. The study was only conducted in Iowa.

Assumptions

A questionnaire survey method for collecting responses was adopted in this study. Following are assumptions in this study.

1. Samples from the personal interview survey of experienced print estimators, production managers and planners, and salespeople are representative of experts.

2. Samples from the group-administered survey of graphic designers, prepress operators, publishers, and junior and senior level students majoring in graphic communications are representative of entry-level users.

3. All participants in the study answered the survey questionnaire completely and honestly.

4. All participants, experts and entry-level users, in the study have some knowledge of and skill in print production or print estimating.

The Design: Methods and Procedures

This study was designed to provide a solution for problems existing in print estimating. Following are details regarding research methods and procedures.

Population

Two categories of users, experts and entry-level users, defined the target population for this study. Experts are individuals who are fully experienced with print estimating such as print estimators, brokers, production managers and planners, and salespeople. Entry-level users are individuals who only occasionally involve themselves with print estimating. They are graphic designers, publishers, advertisers, prepress operators, and college students majoring in graphic communications.

Sample

Samples in this study consisted of two groups, experts and entry-level users. The experts were print estimators, salespeople, and production managers and planners who have worked in their industry positions for at least six months. Entry-level users were graphic designers, prepress operators, publishers in the printing industry, and junior and senior students majoring in graphic communications at the University of Northern Iowa.

Instrumentation

The instruments used in this study included a designed PDF print estimating system, a pilot study of three experts and three entry-level users, a questionnaire for usability evaluation, personal interview and group-administered surveys, and statistical analyses.

Procedures

System design and usability evaluation were the two main stages in this study. The design was based on the conventional method. Following the design stage, a survey of experts and entry-level users was conducted to gather data regarding system capability, layout and design, learnability, and overall satisfaction. The survey responses were then analyzed using statistical tests.

Usability Evaluation Survey

Survey is a technique often used in quantitative research. It is an easy and sufficient method to acquire information from a given population (Balian, 1982; Fowler, 1993). The usability evaluation survey was designed to determine the level of agreement to software usability among participants. A usability inspection focuses on whether the product is designed appropriately and can also identify usability problems in the existing user interface design (Nielsen, 2000; Shneiderman, 1998). Recommendations for improving usability and fixing problems were based on this inspection.

The Survey Questionnaire

The questionnaire design was based on the methods and principles used by Nielsen (2000) and Shneiderman (1998). The questionnaire contained six sections: (a) print estimating experience, (b) system capability, (c) layout and design, (d) learnability, (e) overall satisfaction, and (f) suggestions and comments about the system.

Pilot Study

A pilot study helps the researcher decide whether it is feasible and worthwhile to continue the proposed research. A pilot study can demonstrate the appropriateness of research

procedures and the measures selected as variables. It can provide an opportunity to assess the adequacy and practicality of the data collection instruments. Trying out proposed procedures before the research plan is underway can be helpful. Unanticipated problems can be solved at this stage thereby saving time and effort (Ebel & Frisbie, 1991; Sirkin, 1995). The pilot study for this research was conducted with three print estimators, as expert users, from the printing industry and three junior and senior students, as entry-level users, majoring in graphic communications at the University of Northern Iowa. The printing industry estimators represented experts, and the university students represented entry-level users.

Surveys with Experts and Entry-Level Users

After the pilot study, a series of personal interview and group-administered surveys was conducted. Samples were professional print estimators, salespeople, production managers and planners, graphic designers, and prepress operators from the industry who were conveniently located in Cedar Falls, Hudson, Independence, La Porte, Waterloo, Waverly, and Grundy Center, Iowa. Junior and senior level students majoring in graphic communications at the University of Northern Iowa were also part of the sample. They were

students in one of two classes—Graphic Arts Estimating and Management or Advanced Copy Preparation (see Appendix A). In the usability survey, each participant received an introduction about the designed system and a demonstration of a print estimation, went through two to three estimations with the designed system, and then responded to the related opinion questions in the usability survey questionnaire.

Statistical Analysis

After conducting the usability surveys with experts and entry-level users in this study, a number of *t* tests, independent-samples *t* tests, and one-way repeated-measures ANOVA and paired-samples *t* tests, determined the extent of agreement about software usability and the weaknesses and strengths of the designed system. Finally, a factor analysis identified the patterns of the survey responses.

A Layman's Conclusion

The layman's conclusion is based on the statistical analysis. The conclusion also responds to the purpose of the study and the research questions.

Definition of Terms

A number of special terms were used in this study. The following terms are defined in greater detail to clarify their use.

Mid-Size Print Firms

Mid-size print firms are printing companies with 20 to 49 employees and annual sales of 2 million to 6 million dollars. According to *TrendWatch Report 2000*, mid-size shops hold 60% of total sales in the printing industry, a large portion of the market share (*TrendWatch Report 2000*, n.d.).

Activity-Based Cost Accounting

Activity-based cost accounting takes into consideration all the processes involved in the production of a product. In activity-based cost accounting each process or step of production is cost out. The final cost of the product is based on the actual cost of all the process costs involved in production. Because each product in printing is unique and involves a variety of processes, the activity-based cost accounting method is appropriate and provides the printer and the customer with a true cost or price (Brimson, 1991; Hicks, 1992; Ruggles, 1996).

Portable Document Format (PDF)

As the name implies, Portable Document Format or PDF is a file format that can be opened in most computer platforms without the original application. Adobe Acrobat is the application which creates, edits, and visualizes PDF documents. Because the specifications of the file format are

publicly available, many companies have developed software that is compatible with PDF. The printing industry uses PDF as one of the standard printing workflow formats. It is frequently used as a file format to exchange data between applications and computer platforms (Adobe Systems Incorporated, 2001; Geschke & Warnock, 2000; Leurs, n.d.; Merz, 1996; Padova, 1999).

Software Usability

Software usability is the measurement of how easily a user can learn to operate a computer system. The usability of a computer interface measures the correctness, effectiveness, efficiency, and satisfaction of users (Shneiderman, 1998).

Software usability consists of a number of factors including functionality, flow through the application, and user feedback to the application. Strong usability makes an application easy to learn, easy to use, easy to remember, and subjectively satisfying. Software usability is widely used in the information technology industry and has proven to be a useful tool for improving software application and user interaction especially in the early stages of software or system development (Molich & Nielsen, 1990; Shneiderman, 1998).

Description of Succeeding Chapters

This study designed and evaluated a newly designed PDF print estimating system and then compared it with commercial estimating systems. An expert interview survey elicited professional opinions on usability and a group-administered survey collected usability responses from general users.

Chapter 2 is a review of literature related to this study. It discusses the printing industry, print estimating and accounting, system design, portable document format, software usability, research methodologies, and statistical analysis. Chapter 3 contains detailed descriptions of the system design, the usability evaluation, and the methodology for data collection in this study. Chapter 4 provides the research findings and data analysis of this study. Chapter 5 presents the summary, conclusions, and recommendations based on the statistical data. The recommendations will be used for future development and research.

CHAPTER 2

LITERATURE REVIEW

The Printing Industry

The U.S. printing industry is composed mainly of small and medium-sized companies. The industry employs approximately 6 hundred thousand people working in 35,000 printing facilities with fewer than 20 percent of the firms having more than 20 employees. These numerous small and medium-sized firms help make the printing industry one of the largest manufacturing industries in the United States (*Vision 21*, 2000). In fact printing is the third largest manufacturing business in the United States, beating out the motor vehicle, the airline, and the computer industries (Larson, 2000).

Since the beginning of the 20th century, the developments of new technology and innovation have been changing the world (Bobbitt, 1997). The printing industry has not been immune to these technological advancements. Many technological inventions have modernized the printing process, and the industry has benefited as a result. One such invention is automation. Page composition was previously done manually and one page at a time by the film stripper. Today print companies use the automated

imagesetter or platesetter process which is easy, efficient, and economical.

Today's printing industry is moving toward state-of-the-art technology. What a printing firm does is no longer just an ink on paper process. Instead, it is a business of marketing, customer service, organizing, technology application, information, and distribution. The Printing Industries of America (PIA) has identified three major challenges printers are faced with today: (a) the changing and expanding macroeconomic environment restructuring the trading process, (b) new multimedia advertising and communications reducing the distance between printers and customers, and (c) advanced technologies redefining the printing market (*Vision 21*, 2000). Printing is and will continue to be a challenging business.

The Current Marketplace

Success in today's print market does not just happen; new technologies and media bring opportunities but disturb the printing industry at the same time (Nottonson, 2002). New advanced equipment makes print production less time consuming. However, investment in new equipment is costly and a difficult decision to make. Consultants can give investors no guarantees, and their analyses of returns on

investments are perplexing. New management strategies, market assessments, and sales techniques created by or for the new equipment are even more confusing. But it is just such an investment that will boost a company's sales and provide the best service and product for the customer.

Advances in digital and tonal machines have also changed the print market. A 1998 *Strategies on Demand* report predicted that the digital printing market would grow to 4 billion dollars by 2005 (Fleming, 2002). Digital printing has the ability to combine the power of the computer and the Internet to achieve better customer service while direct mail, variable data printing, and online printing help expand its market share (Gorelick, 2001). Quick turnaround time and the ability to print low volumes at relatively low costs make digital and tonal machines a popular choice.

The traditional printing industry has been affected not only by tonal and digital printing but also by the advent of new media such as the Internet, personal digital assistants (PDAs), and e-books. But traditional commercial printing will continue to have a place in the print market. It is appropriate for high volume print jobs because the unit cost of the print product dramatically decreases as the print volume increases. This is not so with digital printing. The

unit price for digital printing is based on a set of standard characteristics and remains constant regardless of the print volume.

On the macro economic level, today's printing industry market is less demand and over supply (*Vision 21*, 2000). The economic recession has contributed to printer and publisher lack of confidence. Expanding markets created by new technology have brought greater competition, making economic success for some printing firms difficult. In such a competitive market, cutting prices is the first response to declining sales. Cutting prices can procure work to fill production voids and initially create sufficient income to cover the high fixed costs of maintaining operations (Cross, 2002). However, such cuts are not a long-term solution to declining sales. With ever-deepening cuts, a company eventually runs itself out of business.

The integration of technology and service is the key to a value-added product in the present challenging economic climate. Strategies for improving productivity, financial management, and customer service are vital to ongoing success and higher profitability (D. Green, 2000). Computers have integrated printing workflow thus increasing productivity, reducing the cost of each print procedure, and creating a

higher quality product. E-commerce is also part of the growth strategy. The Internet allows a print firm to offer customers service regardless of their locations or time zones (Hurt, 2000). Although new media consume a portion of the print market, they are also a new print market themselves. Because of continuing technological advances and the restructuring market, the future of the printing industry looks bright and exciting.

Print Estimating

A print product is usually a combination of various processes using necessary materials. Unless the product specifications are identified, an estimated price cannot be determined. Without print estimating, it is almost impossible to determine the true price, especially when the production involves many factors. Appropriate pricing is crucial because it provides a greater chance at winning sales and benefits the company at the same time (Margolis, 1992; Merit, 2000).

Because the entire printing business starts at estimating, a print estimator holds one of the singularly most important positions in a print firm. An estimator must regularly update changes in the cost of materials and labor and constantly be aware of all costs related to production

(Silver, 1982). In addition, the actual process of estimating print production costs is complicated. It must take into account cost analysis, pricing, order entry, inventory, production planning, and scheduling. It must integrate these factors into the accounting system as well (Belkin, 2001).

Different accounting methods can be used in print estimating. The activity-based cost estimating method has been widely adopted by different sized print firms as well as by digital image service bureaus, quick printing shops, and graphic design service providers. Its popularity has increased dramatically since being introduced in the 1980s (Ruggles, 1996).

Print Estimating Systems

Print estimating systems can be defined as applications or websites that can determine costs and assist in the production planning. Estimating systems allow print firms to provide a quick response to customers while also generating order invoices, job tickets, and information for accounting. A print estimating system needs to have features that calculate and deliver a concise estimation or price, automate paper flow from the original estimate to the invoice to accounts receivable, and create a web interface between the

customer and the print shop (Crouser Report and Associates, Inc, n.d.). Regardless of the size or production methods of a print firm, these features are crucial for print estimating systems.

Activity-Based Cost Accounting for Print Estimating

Activity-based cost accounting, also known as ABC accounting or cost accounting, is a means of developing a pricing formula for a print estimating system. It is a technique that charges all of an organization's indirect costs to the necessary production activities and then distributes the activities' costs to the products (Brimson, 1991; Hicks, 1992). This provides an accounting system for firms that cannot afford hours of employee time and costly consulting fees for full-scale accounting. Below is a comprehensive description of activity-based cost accounting as described by Hicks (1992).

> Activity-based costing is a cost accounting concept based on the premise that products require an organization to perform activities and that those activities require an organization to incur costs. In activity-based costing, systems are designed so that any costs that cannot be attributed directly to a product flow into the activities that make them necessary and that the cost of each activity then flows to the products that make the activity necessary based on their respective consumption of that activity. (p. 8)

A print product can be as simple as a business card or as complex as a series of encyclopedias. The price of a print product is complicated and cannot be determined solely on print volume. Using the activity-based cost method in print estimating, the first step in cost estimating is to measure the total activities needed to produce the final product. Activities are processes necessary for creating a product. In printing for example, prepress activities alone may include scanning, image manipulation, page composition, and imposition. Once activities for the entire production plan are identified, cost for each operation is assigned. Thus, the total cost of the product is the sum of the costs of all necessary activities or operations (Ruggles, 1996; Williams, 2001).

In traditional cost accounting, the product cost is the sum of manufacturing and overhead costs. It does not truly reflect the characteristics and cost of each individual order. Printing is a manufacturing production industry but not a mass production business. Each print job and product is unique. In mass production businesses, where the same product may be produced year after year, the overall cost is more important than the cost of each activity. Traditional accounting is appropriate for such businesses because the

overhead costs are blended into each product. In activity-based cost accounting, the product cost is the sum of the costs of all involved activities. The cost of each individual order is determined by looking at all its production activities and the cost of each. Accurate product cost allows a print firm to target its products, markets, and customers. Print companies are more profitable when they specialize in products and service rather than pursing high sales volume (Brimson, 1991). Hence, activity-based cost accounting is more appropriate than traditional cost accounting for businesses like printing.

Activity-Based Accounting Print Estimating Procedure

Activity-based cost estimating is the procedure of accumulating all the process costs needed for a product. Using this procedure, a company identifies the production plan that is most productive, thus creating the greatest margin of profit for the company and also providing a competitive price to the customer. Following are the two main steps of cost estimating in print production (Merit, 2000; Ruggles, 1996).

1. The print estimator must develop a production plan for the product that provides for the order to be manufactured most economically and efficiently.

2. After the production plan is developed, the estimator assigns a cost for each activity. The cost of each operation or activity is the manufacturing hourly cost multiplied by the manufacturing time plus material costs. The final price of a print order is then the sum of all activity costs plus buyout costs.

The manufacturing hourly cost or the budgeted hourly cost (BHR) is the hourly cost for a specific manufacturing procedure. For example, it may cost 60 dollars an hour for paper cutting or 250 dollars an hour for offset press running. Material costs are costs of raw materials such as paper or ink and consumable materials such as plates or chemicals. Outside suppliers known as buyouts often provide specialized operations or services outside the plant, and these services need to be taken into account when estimating the cost of a print order. With increased specialization in the industry, buyouts from more than one outside vendor are common in a printing job. The formula for activity-based cost print estimating shown below is the sum of each activity's cost.

Estimated cost or price of a print order =
$\sum$ ((production hours x BHRs) + material costs
+ buyout costs)

Activity-based cost estimating allows a firm to utilize its speed and versatility for a variety of print production methods. When the print market is especially competitive, an efficient and precise cost determination method is tremendously valuable for print firms. Because of its efficiency and precision, the cost estimating method has proven to be the most appropriate method for print estimating since being adopted by the printing industry (Merit, 2000; Ruggles, 1996; Silver, 1982).

General Activities and Material Costs in Print Production

General print production can be divided into three main steps: *prepress*, *presswork*, and *finishing*. Each print order may involve one or more of these steps.

Prepress includes all the processes before mounting plates onto the printing press. It is the most technologically advanced step in print production. Automation has taken over prepress processes and is moving parallel to the development of the computer. It is said the speed of a computer's CPU is doubled every ten months as is the development of prepress. A typical prepress department is equipped with drum and flatbed scanners, computer workstations, networking, and imagesetters or platesetters. Its function is scanning, image manipulation and retouching,

page composition, proofing, and plate making. The materials in the prepress stage normally include proofing paper, plates, and chemicals. Costs for prepress are not usually related to print volumes whereas costs for presswork and finishing increase as print volume rises (Beach et al., 1986; Margolis, 1992; Merit, 2000).

Presswork is the paper and ink process. Running thousands of sheets an hour, the typical offset press is extremely productive. Unfortunately, setup and running costs are high, each costing several hundred dollars an hour. However, when print volume is high, the unit price drops dramatically making the traditional offset process an economical choice.

The cost of paper makes up a good portion of the material costs in presswork. The average paper cost of a print product is 20 to 30% of the total cost (Ruggles, 1996). Compared to paper costs, ink and chemical costs are relatively small. Another concern in presswork is wastage. Wastage of materials is determined by manufacturing difficulty factors and production method. A better quality production or a complicated production plan usually consumes extra materials thus creating more wastage (Margolis, 1992; Merit, 2000; Williams, 2001).

Finishing is the most varied operation in print production; different orders using different processes. Typical processes are cutting, drilling, folding, stapling, binding, and packing. Because the finishing process can be labor intensive and requires a variety of equipment, it is often the most unpredictable cost in print estimating (Margolis, 1992; Merit, 2000).

Trends and Challenges Affecting Print Estimating

The most profound influence on the printing industry has been the emergence of digital imaging technology (Ruggles, 1996). The structure of the print market has been changed by its advent. Unlike the unit cost in traditional print production, which declines as print volume increases, the unit price in digital production remains constant regardless of print volume. This provides a more economical alternative for a customer with a low volume job but takes business away from traditional printing.

Meanwhile, the advent of electronic publishing has shifted the control of publishing from printer to customer. Customers arrive with files ready to print. Even though new technologies have simplified print production, printing still remains a complicated process. For people who are not experienced or trained in printing, unpredictable problems

may arise. This is especially true in the prepress department. It is difficult to determine if a customer-designed document has the correct specifications and appropriate design (Margolis, 1992).

E-commerce or online print estimating has created another challenge for print firms. Once again, problems may arise in this machine-host medium due to the customer lacking print production training or experience. In this new trading environment, estimating is not directly controlled by print estimators. Instead, customers provide specifications, and the estimating system itself develops a price. Such pricing, which is open to the public, can bring about more intense competition—one more challenge to be faced.

Furthermore, production time has been compressed. The average production time in the early 1980s was about 20 days; by the mid-1990s, it was five days or less (Ruggles, 1996). Because of automation and marketplace competition, today's customer expects a shorter production time. This fast-paced environment means customers also expect estimating operations to be performed quickly. The more quickly a customer receives a job quote, the more likely he is to buy. If the quote takes longer than the customer expects, the more likely he will turn to another firm (Crouser Report and Associates, Inc, n.d.).

Investing in new equipment is another concern. It posses a dilemma for today's print firms. New equipment provides better customer service and higher quality, but overall costs increase, meaning a higher price to the customer. It is necessary to investigate the variables related to new equipment. When new equipment is purchased, the production time, production plan, overall cost, and BHR may need to be revised. These revisions are necessary for activity-based cost accounting procedures and to determine the actual new cost of a print job. For example, the installation of a Computer-to-Plate (CTP) system means that new estimating procedures and pricing formulas need to be developed (Ryan, 2000).

System Design

System design is also known as software engineering. It is the application of a systematic, disciplined, quantifiable approach to the direction, development, operation, and maintenance of computer software. Vliet (2000) indicates there are five phases in the development of computer software: requirements engineering, design, implementation, testing, and maintenance.

A typical system design starts with a problem study. The problem to be solved is analyzed and the requirements are

described in a very precise way. Then a system design is generated based on those requirements. Finally, the actual programming process is started. After the software is developed, testing and maintenance refine the software and increase its user satisfaction.

The implementation stage of software design is the process of converting a system specification into an executable system. In many software development projects, system design starts from a set of requirements regarding the targeted problem. Then program coding commences and the design is modified as the system is implemented. A more methodical approach to system design uses structured methods which are sets of notations and guidelines for software design. The use of structured methods normally involves generating graphic system models and creates much documentation (Norris & Rigby 1992; Peters & Pedrycz, 2000; Sommerville, 2001).

System Design Methods

There are a number of design methods. The methods generally consist of guidelines, heuristics, and procedures on how to design a system. Following are three design methods commonly used in the software engineering industry (Vliet, 2000).

Conventional design method. The conventional design method is also known as the data flow design method. Conventional design method has a functional decomposition with respect to the flow of data. Each component is a black box that can transform some input stream into some output stream. Structured analysis and structured design are the two steps of the conventional design method. In structured analysis, a set of data flow diagrams are developed based on the needs of the system. In structured design, the diagrams are transformed into a program using computer language.

Design based on the data structures method. In design based on data structures, a good program reflects the structure in all facets of input and output. Most computer programming languages have structures such as loops or *if* statements. These structures are similar to the concept of the conventional design method, but they have better correspondence in system design. The three stages of design based on the data structures method are modeling, networking, and implementation. The modeling stage converts a real-world problem into a set of computer language structures; the network stage links these structures; and the implementation stage transforms these structures and linkages into sequential computer codes.

Functional decomposition method. In the functional decomposition method the intended function is decomposed into a number of subfunctions each solving part of the problem. The subfunctions may be further decomposed into more primitive functions. The functional decomposition method is similar to the data structures method, but instead of being directed by computer language structures, the functional decomposition method is driven by the subfunctions of the program.

Each design method has unique characteristics suitable for different circumstances. The functional decomposition design method relies on the heuristic knowledge of the designer. Design based on the data structures method provides a well-defined framework for tackling design. The conventional design method has a more dynamic view of the data streams that are the base of the system to be constructed. This method is suited for circumstances where an existing manual system is to be replaced by a computerized system which has exactly the same scenario of print estimating (Peters & Pedrycz, 2000; Vliet, 2000). Therefore, the conventional design method is most appropriate for developing the PDF print estimating system in this study.

Main Activities in Conventional Design

In system design, major decisions of a structural nature are made. Design is information driven. This is especially true in the conventional design method where all activities are directed by data flow charts. Software design encompasses four distinct but interrelated activities: data, architecture, interface, and procedure design. When each of these activities is completed, a comprehensive design model exists for the system (Owles, 1985; Peters & Pedrycz, 2000; Pressman, 1997; Wasserman, 1980).

Data design. This is the first of the four design activities. Data design translates the data objects defined in the problem analysis into data structures. It has a huge impact on the program structure and the procedural complexity of the design system. The purpose of this stage is to select logical representations of data structures. The selection process may involve algorithmic analysis of alternative structures to identify the most efficient design. Good data design can lead to better program structure and reduce procedural complexity.

Architecture design. The objective of architectural design is to generate program modules and the controls between modules. Architecture design provides the software

engineer with a picture of the program structure. Additionally, architecture design may combine program structure and data structure. In the architecture design stage, the main programming construction in system design, the data flow diagram is transformed into program structures.

Interface design. In interface design, interfaces between program modules and between users and software are created. A strong interface design must be created to bring the user and the software together.

Procedure design. Coupled with structured programming concepts, procedure design enables the designer to represent procedural details that facilitate the translation of programming code and the designed system flow.

The choice of software design method is based on the preferences of the designer and the characteristics of the problem, but an appropriate design method must provide sufficient information and direction. Because of the complexities of a print estimating system that works with different media, the conventional method with its data flow design is the proper choice.

Portable Document Format (PDF)

PDF stands for portable document format. A portable document format is a file exchange standard for the purpose

of moving documents across different computer operating systems without the application that originally created the document. Because it is portable, it is in an industrial file exchange standard (Geschke & Warnock, 2000; Merz, 1996; Padova, 1999). Adobe's website describes PDF as "an open standard for electronic documents distribution worldwide." PDF is a universal file format that preserves all the fonts, formatting, graphics, and color of any source documents, regardless of the applications and computer platforms used to create them (Adobe Systems Incorporated, n.d.b, ¶ 1). A PDF document can be shared, viewed, navigated, and printed exactly as intended. The following provides more detail regarding PDF.

Adobe Acrobat and Reader

Adobe Acrobat is the application that creates, views, navigates, prints, and modifies PDF documents. Acrobat allows business, creative, and engineering professionals to exchange documents reliably and efficiently. Acrobat Reader is a free application used to view and print but not to generate and modify PDF documents. Because Acrobat Reader is free to all users, PDF has become increasingly popular as the format for file exchange and distribution (Adobe Systems Incorporated, n.d.a).

In addition to Acrobat Reader, the current Adobe Acrobat family has three other members—Acrobat Professional, Acrobat Standard, and Acrobat Elements. Each member offers different functions that address specific customer needs. Acrobat Professional, the comprehensive set of the Acrobat package, includes support for Computer Assistant Design (CAD) packages and electronic forms. Acrobat Standard can create, modify, and output PDF documents. It can also import data from scanners and handle professional design details. Acrobat Elements is a simple Microsoft Windows-only tool used for quickly generating PDF documents from Microsoft's applications (Taschek, 2003).

PDF and PostScript

PostScript is a page description language. It is a protocol used to communicate between applications and printers. PDF relies on PostScript language to describe all the page elements in a device-independent and resolution-independent manner (Geschke & Warnock, 2000).

The fact that PostScript language is device independent is significant. When a document is printing, the PostScript converts user coordinates to device pixels. This assures that a PostScript file has very similar output results on different output devices. PostScript is also a programming

language with powerful graphic functions that allow it to portray the elements of a page designed to be printed (Merz, 1996).

PostScript has gained wide distribution based on the popularity of desktop publishing and is recognized as the industrial standard for the control of printers and presses. Another advantage of PostScript is its cross-computer platforms capability. PostScript files are made from the American Standard Code for Information Interchange (ASCII) code that can be generated on most operating systems (Geschke & Warnock, 2000).

Although PostScript is very powerful in portraying document elements, it still has shortcomings—a PostScript file cannot be viewed or modified. Based on the structure and development of PostScript, a new document format, PDF, was developed to overcome these failings. The new document format maintains the strengths of PostScript but can also be viewed and modified.

Development of PDF

PDF 1.0 was unveiled in 1992. Acrobat, the tool used to modify and view PDF documents, was released in 1993. PDF 1.0 was designed for the paperless office and had hyperlinks, bookmarks, and font embedment.

PDF 1.1 was released with Acrobat 2.0 in 1994. Several features were added to PDF 1.1. These included external links, article threads, security features, device-independent color space, and notes (Leurs, 2002; Padova, 1999).

PDF 1.2 was released with Acrobat 3.0 in 1996. PDF 1.2 was the first version of PDF designed for prepress. It had features such as forms; support of Open Prepress Interface (OPI); Cyan, magenta, yellow, and black (CMYK) color space; spot color; and halftone functions. PDF 1.2 also started to support a plug-in for Internet browsers and gained dramatically in popularity.

PDF 1.3 was released with Acrobat 4.0 in 1999. It fulfilled the needs of prepress. The updated features of this version were a new color space, smooth shading, and annotations.

In 2001, PDF 1.4 and Acrobat 5.0 were introduced. They satisfied the needs of the prepress and digital printing environment and also started to support JavaScript. Two additional features of PDF 1.4 are its ability to display overprints and to handle a better color management system. It was soon discovered that PDF, which was originally designed for the paperless office, was the perfect format for electronic publishing.

Documents are now more readable and easier to modify because of PDF's capabilities for document exchange and distribution and its cross-computer platform capability. PDF has brought the world closer to the reality of a paperless office and e-book (Merz, 1998). Despite its short history, PDF is the most reliable and exchangeable file format ever developed. More advanced computer technology has made PDF even more flexible, compatible, and universal.

Creating a PDF Document

PDF documents can be created by using PDFWriter or Distiller. Creating PDF with PDFWriter is as simple as output to a printer. It is designed for users who need to only view, distribute, and print from their desktop inkjet or laser printers. It is not appropriate for commercial or high-end digital printing because it eliminates features necessary for the control of high-end printers. Acrobat Distiller is another means for creating PDF. Distiller provides more controls over press and file attributes when developing a PDF document for output. To use Distiller, an Encapsulated PostScript (EPS) or a PostScript file needs to be generated, and then Distiller is used to convert the EPS or the PostScript file into a PDF document (Merz, 1996, 1998; Padova, 1999).

Enhancing PDF Documents

Annotations, *graphic markup tools*, and *text markup tools* can be used for modifying and distributing PDF documents. Within a PDF document, annotations come in the form of notes, sounds, highlights, stamps, and graphics. They can be used for different functions such as instructional manuals or helps. Annotations are like Post-Its that can be attached to PDF documents.

There are four graphic markup tools: pencil, rectangle, ellipse, and line tools. They are used to markup PDF documents with comments, suggestions, and editing. To facilitate editing these tools can also be combined with annotations.

Text markup tools allow users to highlight, strikethrough, and underline text within PDF documents. These annotations can be imported or exported. Exporting annotations is particularly useful when a PDF is distributed to many users and a response is expected (Guthrie, 1998; Merz, 1996; Padova, 1999).

After a PDF document is created, its content can still be modified. Besides adding links and bookmarks, users can edit text and images and insert, record, and extract pages. Additionally, a PDF document can be saved in a rich text

format that can be manipulated by word processors. Images within the document can be saved in a variety of file formats. The entire PDF document can be converted into formats such as Joint Photographic Experts Group (JPEG), Portable Network Graphics (PNG), or Tag Image File Format (TIFF). As a result, a PDF document can be repurposed partially or entirely (Adobe Systems Incorporated, 2000).

Multimedia and Interactive PDF

Besides its capability of maintaining output consistency, PDF is moving toward multimedia and interaction. Audios and movies can be placed within a PDF document. Users can also create form fields that can be filled out. Form fields in PDF documents take the format of text, check box, combo box, radio button, and digital signature. Users can create and modify these fields and can specify calculations or instructions by using JavaScript. JavaScript, which is computer platform independent, allows PDF documents manipulated by it to cross different operating systems (Guthrie, 1998; Merz, 1998). The form fields created using PDF are just like forms within HyperText Markup Language (HTML) web pages and work over the World Wide Web.

Form fields and Internet capability enhance the usage of PDF. PDF forms, which emulate the traditional paper forms

that have text and input fields for users to fill out, can be used for submitting and collecting information over the Internet (Adobe System Incorporated, 2001). In order to do this, a network server with a Common Gateway Interface (CGI) application that collects and routes the data to a database is needed. As the popularity of HTML forms increases, PDF also gains usage by offering forms with better design and friendlier user interface (Merz, 1998). Many companies, organizations, and government agencies have adopted PDF forms over HTML forms or traditional paper forms. Even the Internal Revenue Service (IRS) has adopted PDF forms for collecting taxes. Tax forms can be downloaded from the IRS's website (Guthrie, 1998; Internal Revenue Service, 2003).

Generating PDF for Digital Printing and Prepress

In addition to its dynamic and interactive features, PDF is also an extraordinary application for the printing industry. Many problems experienced in the prepress department can be solved if the output files are in PDF. In the printing industry, the main output devices are high-resolution printers, imagesetters, and platesetters. These output devices create color-separated films or plates at a relatively high resolution. It is recommended that Distiller be used to create PDF files for high-end output. Following

are guidelines for preparing PDF documents (Merz, 1996; Padova, 1999):

1. Select an appropriate PostScript Printer Description (PPD) or printer driver. Each output device has its own features and capabilities. In order to optimize the output result, selecting the correct PPD or driver is necessary.

2. Embed fonts used in the document. One of the major problems in the prepress stage is missing fonts. To avoid this problem, it is recommended that fonts be included in the output documents.

3. Set up the correct halftone frequency. Depending on the needs and the capability of the output device, the halftone frequency can be the default setting or changed manually. If the PDF file is designed for an imagesetter or a platesetter, it is suggested that the halftone frequency be controlled to optimize the output performance.

4. Do not downsample images. Acrobat Distiller can reduce image resolution by selecting the Compression Job Option to reduce the file size. However, doing this in the image processing application instead of in Distiller is recommended (Padova, 1999).

5. Do not convert colors to CMYK color mode. When outputting a PDF document to an imagesetter or a platesetter,

a Raster Image Processor (RIP) can convert all the elements in the document into bit-mapped images. For high-end printing, it is always a good idea to preserve PDF files in Red Green Blue (RGB) color space in order to provide more color information.

Distilling PostScript files. After the PostScript files are properly generated, the next step is distilling those PostScript files into PDF documents. In the Job Options settings, output resolution needs to be the device's mechanical resolution in order to achieve the best quality (Padova, 1999).

Printing PDF documents. When PDF files are printed to high-end output devices, all the page setup properties require the use of the specific PPD or the printer driver. Process colors (CMYK) can be processed by RIP without extra effort when printing. The output result is always guaranteed because the format integrates all the page elements within the document.

PDF and Color Management System

A color management system (CMS) is a collection of software tools designed to reconcile the different color capabilities of input and output devices. It assures consistent color reproduction for different output devices

such as applications, monitors, printers, and commercial presses (M. R. Adams & Weisberg, 1998). With CMS, colors displayed on the monitor are the same as the final output. Because all versions of PDF adopted CMS, a PDF document can assure the same color performance throughout assorted output devices (Padova, 1999).

Software Usability

Software usability is defined by Booth (1980, p. 7-8) as "the degree to which specific users can achieve specific goals within a particular environment effectively, efficiently, comfortably, and in an acceptable manner." Mandel (2002) defines it similarly noting that usefulness, effectiveness, learnability, and attitude are the critical factors determining software usability. Focusing on the user, Nielson (2000) is more explicit in his definition. How easily and quickly can the software be used? Can the user return to the software at a later time and not have to relearn it? What is the seriousness and frequency of user problems and software errors? Finally, what is the subjective level of user satisfaction with the software? Software usability can be called the glue that holds all the software pieces together.

Why Software Usability Is Important

Software usability depends on a number of factors including the functionality that fits user needs, the flow through the application that fits user tasks, and the response of the application that fits user expectations. Software with strong usability can be easily learned, used, and remembered, and is subjectively satisfying (*Usability First*, 2002). Usability is important is that it improves the application itself and also the interaction with end users. Sometimes it even affects the success or failure of a system.

Goals of Software Usability Design

Successful designers have a thorough understanding of their diverse users and the tasks needing to be accomplished. Their focus is not solely on user friendliness. Effective systems generate positive feelings of success, competency, mastery, and clarity for the user. Shneiderman (1998) indicates the following as goals in software usability.

1. Proper functionality. This is the first thing users look for. Inadequate or excessive functionality is not good design.

2. Reliability, availability, security, and data integrity. New systems do not easily and immediately meet users' expectations and achieve high satisfaction. Attention

to these factors ensures a higher level of initial satisfaction.

3. Standardization, integration, consistency, and portability. Expectations caused by increased computer and Internet usage have pressured designers to consider these factors.

Designer attention to these goals shortens user learning time, increases performance speed, reduces user error rate, extends retention time, and increases subjective satisfaction (Nielsen, 2000).

Conducting a Software Usability Evaluation

The primary purpose of usability evaluation is to increase user satisfaction of the system. Usability inspection can be conducted at many stages during and after the design and development processes, but the aim of such evaluations is to find usability problems before an application is released into the market. A variety of approaches to usability evaluation are available. Factors such as the cost of the evaluation, the time constraints of the project, and final users need to be considered when selecting the evaluation method. In consideration of these factors, a survey questionnaire was deemed the most reasonable method for this study.

Software Usability Studies

A usability study is a critical step in the development of commercial software. For example, Visse, lead product manager for MSN at Microsoft, said the usability studies for Microsoft Network helped it to be one of Microsoft's most consumer-friendly products ever. Microsoft's objective is to make sure its products are useful, usable, and enjoyable (Redmond, 2000).

Microsoft Network (MSN) also used a software usability study to investigate the usability of web sites. This study generated information on web site appeal, a site review checklist, and a list of concrete design tips. These ideas were applied to Microsoft's webpage. Five main attributes were determined to increase a webpage's usability: (a) relevant, high quality content, (b) easy use, (c) effective promotion, both on the site and in other media, (d) an experience unique to the medium, and (e) emotional appeal (Keeker, 1997).

Software usability is critical when users are considering which application to buy. The Boeing Corporation is changing the way it buys software and is making a product's usability—the ease with which end users can be trained on and operate the product—a fundamental purchasing

criterion. It's a move the aerospace giant sees as an important way of reducing information technology costs (Thibodeau, 2002).

Boivie (1998) indicated "easy to use" is the key for software to be successful. People usually focus on features when they look at an application, but ignore usability. Little attention is paid to how easy the application will be to use. An over-designed or difficult-to-use application usually limits user productivity and raises costs.

In 1996, a comparative study on tax-preparation applications was conducted by Cury, Hogan, Leonhard, and Austin. The concept of usability was applied in this study to compare four tax-preparation applications: Kiplinger TaxCut, TurboTax Deluxe, Personal Tax Edge, and Simply Tax. The study found that Block Financial's Kiplinger TaxCut and Intuit's TurboTax Deluxe to be the only products that are easy enough for use by novices.

Besides the commercial studies, several dissertations have focused on usability. The primary focus is on usability for web sites and applications.

A study in measuring usage and usability of online databases was conducted at Hartnell College. This study identified factors that affect user satisfaction and the

effectiveness ratings of existing electronic resources and resulted in planned revisions for future database development (Lagier, 2002).

Pane (2002) indicated that programming is a notoriously difficult activity and some of this difficulty can be attributed to the poor usability of the designs of programming languages and tools. In his dissertation study, a new programming system was developed for children with unique features for new users. The effectiveness of these features was determined important for creating programming systems.

A research study to determine the relationship of web site design and usability was conducted in 2001 by Xiang. The study identified factors that may influence web site usability. The study resulted in guidelines for web site design.

Another research study for evaluating the usefulness and usability of a web site was conducted by Zimmerly in 2002. The instructional design method was used to build the web site and a usability survey technique was used to evaluate it. Zimmerly concluded that the web site was both usable and useful and that the design method was employed effectively to produce the accreditation web site.

Based on the literature review, usability is the primary method for determining software or web page usefulness. In addition, it should be noted that most of the studies used a survey method for obtaining usability information.

Software Usability Survey

Survey is a technique for acquiring information from numbers of people within a given period. It is an easy, quick, inexpensive, and accurate method for conducting research involving the public. A survey gathers data by asking questions of a sample or a portion of a focused population. It is one of the methods commonly used in business, political science, sociology, psychology, and educational research. Studying the whole group a researcher is interested in may be too time consuming or just not feasible. Instead, a survey studies part of the target population and makes inferences about the whole population (Alreck & Settle, 1995; Ary, Jacobs, & Razavieh, 1996).

Software Usability Questionnaire

A research questionnaire is a good method for acquiring assessment data because it permits anonymity and is answered in the respondent's own time. It provides more accurate self-reported data if confidentiality can be ensured (Pratt, 1980). The questionnaire should be short, easy to

understand, and its content directed by the focus of the research (Ary et al., 1996).

Researchers are often interested in a population's attitudes or feelings toward a particular product or issue. The Likert scale is one of the most widely used techniques to measure attitudes. It is appropriate for relatively simple questions with an average spread of expected responses. The scale asks respondents to rate their attitude on a numerical scale turning qualitative response into quantitative data. This is typically done for a large number of statements related to the research (Balian, 1982).

Personal Interview Survey

A personal interview survey uses a question-asking approach. The research interviewer reads the questions in a face-to-face setting and records the respondent's answers. A personal interview is flexible in that the interviewer can clarify and answer any questions the respondent might have. Under these circumstances, responses tend to be more in-depth and thorough. Problems can arise because of the face-to-face interaction. When seated across from the interviewer, respondents may be more likely to say what they think the interviewer wants to hear. Also, the way in which questions are worded by the interviewer may change from one interview

to the next, thus there is a relatively greater chance of the interview influencing the responses to questions (Alreck & Settle, 1995; Creswell, 1994).

Group-Administered Survey

A group-administered questionnaire survey is conducted with a specified group of respondents in a controlled environment. As a result, response rate is high and the cost is relatively low. The quality of data received tends to be strong because respondents can receive help in interpreting questions, but it may lack depth and thoroughness (Alreck & Settle, 1995).

Statistical Analysis

Statistics provides a body of principles and methodology for designing the process of data collection, summarizing and interpreting the data, and drawing conclusions (Johnson & Bhattacharyya, 2001). In this study, a number of statistical methods were used. They are coefficient alpha and split-half coefficient estimates for survey response reliability analysis, one-sample *t* tests for usability agreement level evaluation, one-way repeated-measures ANOVA tests for comparing sections and items, independent-samples *t* tests for item and section comparison of the two user groups, and factor analysis for variable pattern analysis.

Coefficient Alpha and Split-Half Coefficient

A reliability analysis calculates a number of commonly used measures of scale reliability and provides information about the relationships between individual items in the scale (Ebel & Frisbie, 1991).

Coefficient alpha is one internal analysis method for evaluating the reliability of a single test. Coefficient alpha can provide a reliability estimate for a measure composed of items scored with values other than 0 and 1 (Cronbach, 1951). This is appropriate for a survey questionnaire with numerical values rating attitudes from "strongly agree" to "strongly disagree." Split-half coefficient and coefficient alpha estimates can be used to estimate the reliability of the total score if a scale has multiple items and the multiple items are summed to obtain a total score (B. S. Green et al., 1997).

One-Way Repeated-Measures ANOVA

One-way repeated-measures ANOVA analyzes variance by considering a design that is a logical extension of the dependent- or correlated-sample *t* test. It is commonly used for situations in which it is either necessary or desirable to have the experimental subjects serve in all the treatment conditions (Christensen & Stoup, 1991).

Several distinct advantages are associated with a one-way repeated-measures ANOVA. First, it is the efficient use of the research subjects. Because each subject contributes a score to each treatment condition, a one-way repeated-measures ANOVA requires fewer subjects. Therefore, this method is highly desirable when research subjects are either difficult to obtain or costly to run. Because the same subjects serve throughout the research in an independent-groups design, there is a certain amount of random variation which creates higher error. The second advantage of one-way repeated-measures ANOVA is the reduction of such error or random variability in the research (Hurlburt, 1998).

Factor Analysis

Factor analysis is used to identify underlying variables or factors that explain the pattern of correlations within a set of observed variables. It is commonly used in data reduction to identify a small number of variables that explain most of the variance observed in a larger number of manifest variables.

Factor analysis can be treated as a data-reduction technique since it reduces a large number of overlapping measured variables to a smaller set of factors. More important, the factors can correspond to identify

unobservable latent variables of a theory that helps people understand behavior (B. S. Green et al., 1997).

Summary

The advent of new technological innovations and e-commerce has had a tremendous impact on the printing industry. It has changed print production, marketing, sales, and also print estimating. Today's computer-driven market demands a universally compatible print estimating system. This type of estimating system can help print companies gain more sales and greater profits while providing better service. Furthermore, it can improve the management and productivity of print firms.

The designed print estimating system was built based on the conventional design method. The usability of this newly designed software was evaluated using a survey technique. Finally, coefficient alpha and split-half coefficient estimates, one-sample *t* tests, independent-samples *t* tests, one-way repeated-measures ANOVA tests, and factor analysis statistical testing methods were applied to provide a thorough analysis of this innovation—a PDF print estimating system.

CHAPTER 3

METHODOLOGY

This study consisted of two main stages: designing a PDF print estimating system and evaluating its software usability. In the system design stage, a conventional design method was adopted to provide structures and directions in developing the PDF print estimating system. In the software usability evaluation stage, a serious of survey was conducted with experts and entry-level users. In this chapter, details regarding the methods and the procedures of the design and the evaluation of the PDF print estimating system will be discussed.

System Design

The design method used in this study was data flow design. Data, architecture, interface, and procedure design are the four main activities of this method (Pressman, 1997). The data flow design method is suited for programs such as print estimating where a transfer from a manual to a computer system is needed. Following are steps in developing the PDF print estimating system.

Data Design

Data design is the first step of software engineering. Regardless of the design techniques used, well-designed data

can lead to better program structure and modularity and also reduce procedural complexity. The purpose of data design is to select logical representations of data objects identified during the requirements definition and specification phase.

In order to identify functions and estimation formulas needed in the design of the PDF print estimating system, a study of data objects, relationships, data flow, and content was made. The data design study consisted of several typical print orders: a 12-page color catalog, a 32-page color brochure, and a 64-page color booklet with coated cover.

Architecture Design

The primary objective of architecture design is to develop the program. This step melds program structure and data structure enabling data to flow throughout the program. The following are steps in architecture design.

1. Data flow diagram. A data flow diagram is a graphic technique that depicts information flow and transforms applied data as that data moves from input to output. In the designed print estimating system, inputs consisted of entities from different professional levels of user groups, experts and entry-level users, and a company profile. Outputs of the designed system were a worksheet for print estimates, an invoice for customer, a job ticket for print

firm's internal usage, and an online submission for online print estimating (see Figure 1).

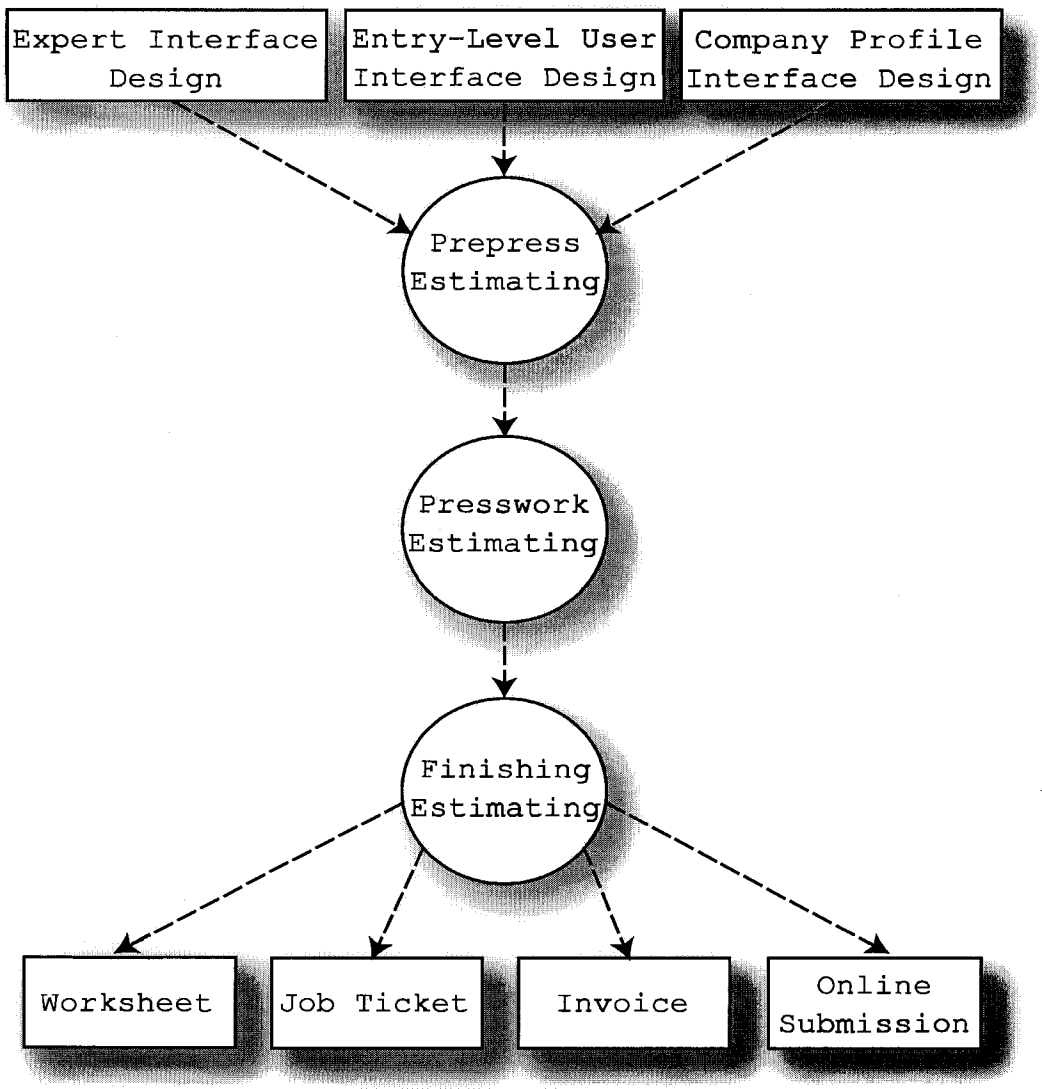

Figure 1. The data flow diagram of the PDF print estimating System.

2. Simulation template. After the data flow diagram was developed, a simulation template was generated to test output results. A print estimating system is extremely complicated,

especially when it is designed in PDF and manipulated by JavaScript. In order to confirm data design and data flow, it is helpful to simulate the design print estimating system in a simplified form. Therefore, a print estimating simulation template was developed by using a spreadsheet application to simulate output results and system flow.

3. Design steps. Pressman's (1997) steps of architecture design were applied in the design of the PDF print estimating system. The six steps are (a) review the fundamental system model, (b) review and refine data flow diagrams for the software, (c) determine whether the data flow diagram has transformation or transaction flow characteristics, (d) isolate the transformation center by specifying incoming and outgoing flow boundaries, (e) perform factoring, and (f) improve software quality.

Interface Design

The arrows flowing into and out of each data flow diagram are mapped into an interface design of the system that corresponds to the data flow diagram. The interface design of the print estimating system follows not only the data flow diagram but also simulates paper forms such as worksheets, invoices, and job tickets used in the printing industry. The interface design used in the designed print

estimating system can provide a highly satisfying interface design.

Procedure Design

Procedure design occurs after data, architecture, and interface designs have been completed. People who are not familiar with print estimating may not fully understand the sequence or specification of the designed system. In the designed PDF print estimating system, navigation buttons such as *worksheet, invoice, job ticket, company profile,* and *top of page* and function buttons such as *submit, reset, export, file import,* and *file export* (see Appendix B) were added after the main structure was built. These buttons represent procedural detail to facilitate the user's ability to conduct print estimating with less effort.

Additionally, Hot Help, a short description of each field in the PDF document, was set up to provide instant assistance for users. Useful suggestions or descriptions pop up whenever the mouse cursor loiters over a field.

The designed PDF print estimating system is a combination of print estimating knowledge and technique and computer software design. The conventional design method proved to be appropriate because it provided clear directions and structures for designing such a complex system.

Software Usability Evaluation

After the print estimating system was developed, a personal interview survey with experts and a group-administered survey with entry-level users were conducted. These two sample groups have different needs and levels of understanding in regards to print production and print estimating. The purpose of the surveys was to examine the usability of the designed system itself and compare its usability with existing commercial print estimating systems at the same time.

Usability Questionnaire

The questionnaire consisted of six sections: (a) print estimating system experience, (b) system capabilities, (c) layout and design, (d) learnability, (e) overall satisfaction, and (f) suggestions. Section one identified the professional level of participants. Section two examined the capabilities and functions of the designed print estimating system. Section three evaluated the screen layout and design of the system. Section four tested the level of ease in learning the designed print estimating system. Section five inspected overall satisfaction of the designed print estimating system. Sections 2 to 5 provided an overall measurement of usability. Section six was used to acquire

further information from participants that could potentially improve the software (see Appendix C).

Usability inspection has been adopted for system design and evaluation since the 1970s and has shown that it can improve user satisfaction with new software. The usability questionnaire used in this study proved this to be true.

Pilot Study

After the print estimating system was designed and the survey questionnaire was developed, a pilot study was conducted. Three print estimators and three junior and senior students majoring in graphic communications at the University of Northern Iowa participated. The purpose of the pilot study was to validate whether or not the design of the survey was appropriate. The pilot study provided valuable ideas for modifying the design of the survey.

Software Usability Evaluation with Experts

Experts in this study consisted of print estimators, production managers and planners, and salespeople who had held their positions for at least six months. For the purpose of convenient sampling participants came from Cedar Falls, Hudson, Independence, La Porte, Waterloo, Waverly, and Grundy Center, Iowa. These individuals are print firm employees most familiar with print estimating systems. Such

individuals may prefer a print estimating system with more features and controls. The six-month period criterion ensured survey respondents who had fuller understanding of print estimating operations and were experienced in at least one print estimating system. The responses of this focused sample to the open-ended question in each section of the questionnaire provided valuable information for future development and research.

Software Usability Evaluation with Entry-Level Users

Entry-level users in the study consisted of graphic designers, prepress operators, and publishers who were conveniently located in Cedar Falls, Hudson, Independence, La Porte, Waterloo, Waverly, and Grundy Center, Iowa, and junior and senior students majoring in graphic communications at the University of Northern Iowa. These students were in Graphic Arts Estimating and Management or Advanced Copy Preparation. Because such people have less experience in print estimating, they represented users with less skills and experience—graphic designers, publishers, authors, and individuals ordering print jobs online. Such users may expect a more explicit estimating system with fewer features that takes less time and effort to learn. The sample of entry-level users responded to the same close- and open-ended questions

as the expert sample but some of them were in a group-administered format rather than a personal interview format.

Survey Data Analysis

After conducting the usability surveys with experts and entry-level users, the Statistical Package for Social Sciences (SPSS) was used to analyze the responses. The first analysis compared the general software usability of experts and entry-level users. For this analysis, an one-sample *t* test and an independent-samples *t* test were adopted. The second comparative analysis was a software usability comparison of the two levels of users for each section and item. The statistical method used in this analysis was a one-way repeated-measures ANOVA and paired-samples *t* test. Finally, a factor analysis was used to identify underlying variables that explain the pattern of correlations within a set of observed variables in the software usability survey.

Summary

Because a transfer from a manual to a computer system was needed, the conventional design method was selected as the most appropriate for designing the system. The method provided a systematic and logical means for building the new software. After data objects functions and estimation formulas were identified, the software program was developed.

Interface and procedure design developed a clear means of navigating and interacting with the designed program.

A questionnaire was developed to examine the usability of the designed print estimating system. A pilot study involving three print estimators and three university students tested its appropriateness and consequent modifications were made. Using Likert-scale and open-ended responses to questions, expert and entry-level users rated their attitudes on the system's capabilities and its layout and design.

Survey responses were analyzed using a number of statistical methods. Coefficient alpha and split-half coefficient estimates were used to evaluate the reliability of the study. One-sample *t* tests, independent-samples *t* tests, and one-way repeated-measures ANOVA tests provided statistical viewpoints of answers and comparison to each research question and each section of the research. A factor analysis was also applied to inspect the pattern of responses to the research items.

CHAPTER 4

ANALYSIS OF DATA AND FINDINGS

In this chapter the analyzed responses from surveys with experts and entry-level users regarding software usability of the designed PDF print estimating system are presented. Fourteen Likert scale questions and five open-ended questions provided both quantitative and qualitative approaches for the survey questionnaire. After collecting data from the survey, a number of statistical methods were used to analyze the data. The methods used in this study were (a) spit-half coefficient and coefficient alpha, (b) one-sample *t* test, (c) independent-samples *t* test, (d) one-way repeated-measures ANOVA and the paired-samples *t* test, and (e) factor analysis.

Because surveys conducted in this study used personal interview and group-administered methods, the study provided not only descriptive statistical information but also valuable feedback from participants. Survey responses were more in depth because of the face-to-face interaction between the interviewer and the participants. Following are survey responses in detail, a reliability test, a general software usability analysis, findings for the research questions, findings of differences between items, a comparison of sections and items, and a factor analysis.

Survey Response

A total of 64 responses were collected from the two groups of printing industry and educational institution participants (see Appendix D). First each participant received an introduction of the designed system and a demonstration of a print estimation. Then participants performed two to three typical print estimations with the designed PDF print estimating system and evaluated the designed system by answering the software usability evaluation questionnaire. The target samples in this study were people involved with print estimating systems and online print estimating. The professional characteristics of the survey participants are shown in Table 1.

Table 1

Sample Characteristics of Participants

Survey Participant	Frequency	Percentage
Expert User		
Print estimator	12	18.75
Salesperson	8	12.50
Production planner and manager	6	9.38
Entry-Level User		
Graphic designer	8	12.50
Prepress operator	7	10.94
Publisher	6	9.38
Graphic communications student	17	26.55
Total	64	100.00

The section numbers for the survey questionnaire are shown in Table 2 along with the related variables and abbreviations. Abbreviations were used instead of questions to show the 14 items more efficiently when conducting statistical analysis. The mean scores, standard deviations, and rank order of the two user groups combined survey responses are shown in Table 3 and the mean scores, standard deviations, and rank orders of expert and entry-level user responses are shown in Tables 4 and 5. The response values in the Likert scale are 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

Table 2

Survey Sections and Variables

Section	Abbreviation		Variable
2	EC	=	Estimation capability
2	OC	=	E-commerce capability
2	SR	=	System reliability
2	EE	=	Estimating efficiency
2	SU	=	System updating
3	VD	=	Visual design
3	CO	=	Content organization
3	DF	=	Design flow
3	RL	=	Readability level
3	LG	=	Language
3	PC	=	Printout consistency usage
4	EL	=	Ease of learning
4	HH	=	PDF Hot Help
5	OS	=	Overall satisfaction

Table 3

Combined Survey Responses for the Two User Groups

Section	Abbreviation	N	Mean	Std. Deviation	Rank
2	EC	64	3.05	.52	14
2	OC	64	3.34	.54	6.5
2	SR	64	3.28	.58	11
2	EE	64	3.08	.67	13
2	SU	64	3.33	.54	8
3	VD	64	3.48	.59	3
3	CO	64	3.59	.53	1
3	DF	64	3.47	.56	4
3	RL	64	3.30	.61	10
3	LG	64	3.34	.62	6.5
3	PC	64	3.31	.53	9
4	EL	64	3.52	.53	2
4	HH	64	3.16	.65	12
5	OS	64	3.38	.52	5

Table 4

Survey Responses for the Experts

Section	Abbreviation	N	Mean	Std. Deviation	Rank
2	EC	26	2.96	.60	13.5
2	OC	26	3.50	.58	4.5
2	SR	26	3.15	.61	10.5
2	EE	26	2.96	.82	13.5
2	SU	26	3.38	.64	6.5
3	VD	26	3.54	.58	3
3	CO	26	3.69	.55	2
3	DF	26	3.50	.65	4.5
3	RL	26	3.12	.59	12
3	LG	26	3.27	.67	9
3	PC	26	3.38	.64	6.5
4	EL	26	3.73	.45	1
4	HH	26	3.15	.83	10.5
5	OS	26	3.35	.49	8

Table 5

Survey Responses for the Entry-Level Users

Section	Abbreviation	N	Mean	Std. Deviation	Rank
2	EC	38	3.11	.45	14
2	OC	38	3.24	.49	11
2	SR	38	3.37	.54	7.5
2	EE	38	3.16	.55	12.5
2	SU	38	3.29	.46	9
3	VD	38	3.45	.60	2.5
3	CO	38	3.53	.51	1
3	DF	38	3.45	.50	2.5
3	RL	38	3.42	.60	4
3	LG	38	3.39	.59	5.5
3	PC	38	3.26	.45	10
4	EL	38	3.37	.54	7.5
4	HH	38	3.16	.49	12.5
5	OS	38	3.39	.55	5.5

Reliability of Data

The reliability analysis focused on the properties of measurement scales and the items that make them up. The reliability test examined a number of commonly used measures of scale reliability and provided information about the relationship between individual items in the scale. If items on a rating scale are ambiguous and require individuals to often guess, consistency among items will be lacking and internal consistency estimates of reliability will be small. The split-half coefficient and the coefficient alpha methods were adopted in this study for evaluation of internal consistency of the survey responses.

Two internal consistency estimates of reliability were computed for the software usability survey scale: a split-half coefficient and a coefficient alpha. For the split-half coefficient, the scale was split in two so that the two halves would be as equivalent as possible. The even-numbered quantitative items formed one group and the odd-numbered items formed the second group. The first half included estimation capability, system reliability, system updating, content organization, readability level, printout consistency usage, and PDF Hot Help; while the other half included e-commerce capability, estimating efficiency, visual design, design flow, language, ease of learning, and overall satisfaction. Indicating satisfactory reliability, both values for the split-half coefficient and the coefficient alpha were .90 (see Appendix E). These results support the conclusion that the software usability survey items have relatively high reliability and have the potential to make clear inferences about the research.

General Software Usability Analysis

One of the main purposes of the usability survey was to determine to what extent final users agreed that the designed system is usable. In the survey questionnaire, the Likert scale used a four-point scale: (a) 1 = strongly disagree,

(b) 2 = disagree, (c) 3 = agree, and (d) 4 = strongly agree. The median is 2.5 which represents neutral on the attitude scale (see Appendix F). The one-sample *t* test procedure was first conducted to determine whether the mean value of general usability scores differed from the median.

The one-sample *t* test conducted on the usability evaluation survey revealed a mean score for participants significantly different from 2.5, $t\ (63) = 17.59$, $p < .001$ (see Appendix F). The sample mean and the standard deviation of general software usability survey scores were 3.33 and .38 respectively. The effect size *d* of 2.20 indicates a large effect. Figure 2 shows the distribution of software usability survey scores. The results tend to suggest that final users agree that the system has usability.

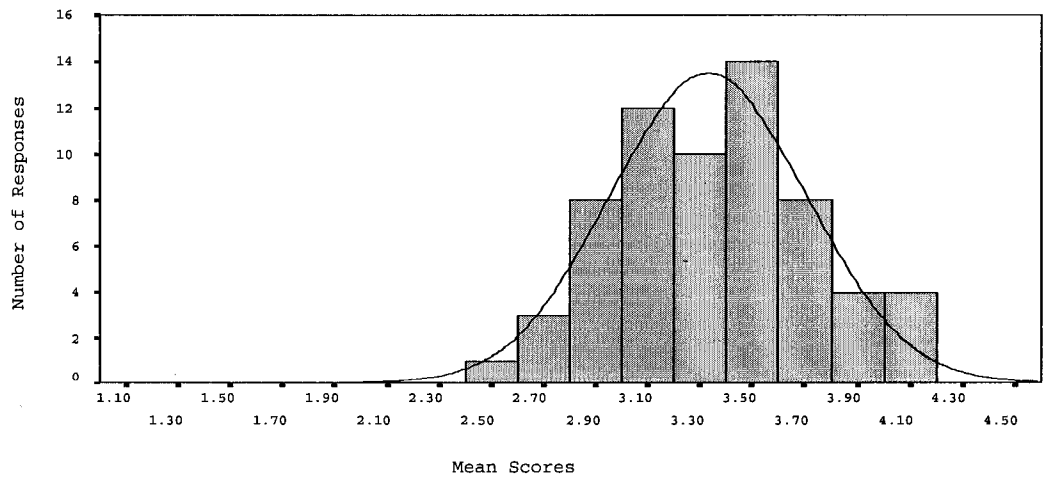

Figure 2. Distribution of software usability evaluation survey scores.

The independent-samples *t* test was conducted to determine whether the expert users had different average responses to general software usability than the entry-level users. The test results did not show a significant difference, $t\ (62) = .08$, $p = .93$ (see Appendix F). The experts ($M_{exp} = 3.34$, $SD_{exp} = .37$) did not respond on the average differently than the entry-level users ($M_{elu} = 3.33$, $SD_{elu} = .39$). Table 6 shows the means of the usability survey responses of the two user groups and the significant value of the comparison.

Table 6

Means of the General Software Usability Survey Scores

	M_{exp}	M_{elu}	P
General Software Usability	3.34	3.33	.93

Findings for the Research Questions

The following are findings for the five research questions posed in chapter 1. The findings are based on survey responses. A number of one-sample *t* tests were conducted to provide answers to the research questions. In the following analyses, if the observed mean is greater than the 2.5, neutral response on the Likert scale and the significant value (p) is lower than .05 then the data

indicate that the designed system provided a significantly positive response to the specific research question.

Research Question 1

Section 2 of the questionnaire was designed to evaluate system capability and to reply to Question 1. Question 1 asked whether the designed PDF print estimating system provided correct estimates for a variety of print orders.

The one-sample *t* test conducted on the system capability section indicated a mean score for participants significantly different from 2.5, $t\ (63) = 14.96$, $p < .001$ (see Appendix G). The sample mean and the standard deviation of Section 2 were 3.22 and .38 respectively. The effect size *d* of 1.87 indicates a large effect. The results tend to suggest that final users agree that the designed PDF print estimating system has system capability.

Research Question 2

Research Question 2 asked whether the designed system has adequate capabilities for both user groups. Section 2 of the questionnaire, which was designed to evaluate system capability, replied to Research Question 2 because the survey was conducted separately with both user groups.

The one-sample *t* test conducted on expert responses to the system capability section indicated a mean score

significantly different from 2.5, t (25) = 8.53, p < .001 (see Appendix G). The sample mean and the standard deviation of expert responses to Section 2 were 3.19 and .41 respectively. The effect size d of 1.67 indicates a large effect. The results seem to indicate that expert users agree that the designed system has adequate print estimating capabilities.

Another one-sample t test was conducted on entry-level user responses to the system capability section. The test results indicated a mean score significantly different from 2.5, t (37) = 12.37, p < .001 (see Appendix G). The sample mean and the standard deviation of entry-level user responses to Section 2 were 3.23 and .36 respectively. The effect size d of 2.01 indicates a large effect. The results tend to indicate that entry-level users also agree that the designed system has adequate print estimating capabilities.

Because the t tests indicated both user groups significantly agreed that the designed system's capabilities were adequate and the previous independent-samples t test revealed that the responses of both groups were not significantly different, the results suggest that the designed PDF print estimating system has adequate capabilities for print estimating.

Research Question 3

Research Question 3 was concerned with comparing responses of experts and entry-level users related to system usability. The mean score of the 14 quantitative survey responses was used to answer this question. The results of the previously conducted independent-samples *t* test indicated that the two groups did not respond differently to the general software usability of the designed system.

In order to further test the survey response, another one-sample *t* test was performed using 3.0 as the test value rather than the previously used lower value of 2.5. This one-sample *t* test conducted on the survey responses indicated a mean score for participants significantly different from 3.0, $t\ (63) = 7.0$, $p < .001$ (see Appendix G). The sample mean and the standard deviation of the software usability survey responses were 3.33 and .38 respectively. The effect size *d* of .88 indicates a large effect. The results tend to indicate that final users, regardless of expertise level, agree that the designed print estimating system has software usability.

Research Question 4

Research Question 4 asked how the designed PDF print estimating system compared with commercial print estimating

systems. Section 5 of the survey questionnaire was designed to answer this question.

The one-sample *t* test conducted on the overall satisfaction section indicated a mean score for participants significantly different from 2.5, $t\ (63) = 13.48$, $p < .001$ (see Appendix G). The sample mean and the standard deviation of Section 5 scores were 3.38 and .52 respectively. The effect size *d* of 1.69 indicates a large effect. The results tend to suggest final users agree that the designed PDF print estimating system has software usability equivalent to commercial print estimating systems.

Research Question 5

This study was designed not only to evaluate the designed system quantitatively but also to acquire qualitative information from survey participants. Research Question 5 asked what suggestions and recommendations experts and entry-level users had for the designed PDF print estimating system.

From responses to the open-ended questions, it seems both expert and entry-level users agreed that the designed system has software usability. They responded positively to new features of the system such as versatility of the PDF, layout and flow design, and the easy learning procedure.

They thought the online estimating, the file embedding, and the quick updating functions would prove valuable in print production. Final users tend to agree that the designed system can eliminate existing problems in print estimating production and commercial print estimating systems.

Findings of Differences Between Items

A one-way repeated-measures ANOVA procedure was used to test differences between item responses. The mean and standard deviation for each item of the software usability survey are presented in Table 3. The results of the ANOVA test indicated the difference between item responses was significant, Wilks' $\Lambda = .53$, $F\ (13, 63) = 3.44$, $p = .001$, multivariate $\eta^2 = .47$ (see Appendix H).

A paired-samples t test was conducted as a follow-up test to identify the differences among the individual item means. The Holm's sequential Bonferroni method was used to control for Type I error across the 91 tests in this analysis (see Appendix H). The results indicated that survey participants responded at a significantly higher level of agreement to e-commerce capability, system updating, visual design, content organization, design flow, language, ease of learning, and overall satisfaction items (see Table 7).

Table 7

Results of the Pairwise Comparison of Items

	EC	OC	SR	EE	SU	VD	CO	DF	RL	LG	PC	EL	HH	OS
EC		*			*	*		*		*		*		*
OC	*													
SR							*							
EE						*	*	*				*		*
SU	*						*							
VD	*			*								*		
CO			*	*	*				*		*		*	
DF	*			*										
RL							*							
LG	*													
PC							*							
EL	*			*		*							*	
HH							*					*		
OS	*			*										

Note. * denotes significant value $p < .001$.

Comparison of Sections and Items

Following are analyses of the items in each section and the qualitative feedback for each section. In the survey questionnaire, Section 1 was used to identify the level of experience of participants with print estimating systems. Section 2 focused on system capability; Section 3 looked into the visual layout and content design; Section 4 was concerned with ease of learning; and Section 5 examined the overall software usability satisfaction of the designed system.

A one-way repeated-measures ANOVA test was used to test differences between sections. The results of the test indicated that the difference between section responses was significant, Wilks' $\Lambda = .70$, $F(3, 63) = 8.90$, $p < .001$ (see Appendix I).

A paired-samples *t* test was conducted as a follow-up to identify the differences among the individual section means. The Holm's sequential Bonferroni method was used to control for Type I error across the six tests (see Appendix I). The results indicated that participants responded at a significantly higher level of agreement to Sections 3 and 5 (see Table 8).

Table 8

Results of the Pairwise Comparison of Sections

	Section 2	Section 3	Section 4	Section 5
Section 2		**		*
Section 3	**			
Section 4				
Section 5	*			

Note. * denotes significant value $p < .05$.
** denotes significant value $p < .001$.

Section 2: System Capability

Section 2 consisted of five quantitative questions and one qualitative question about the system capability of the designed system. Following are analyses of each item using

independent-samples *t* tests and suggestions and comments from Section 2.

Estimation capability (EC). This item was designed to identify whether the designed system is as capable for print estimating as commercial systems. The mean score of item EC was the lowest of all the quantitative items (see Figure 3).

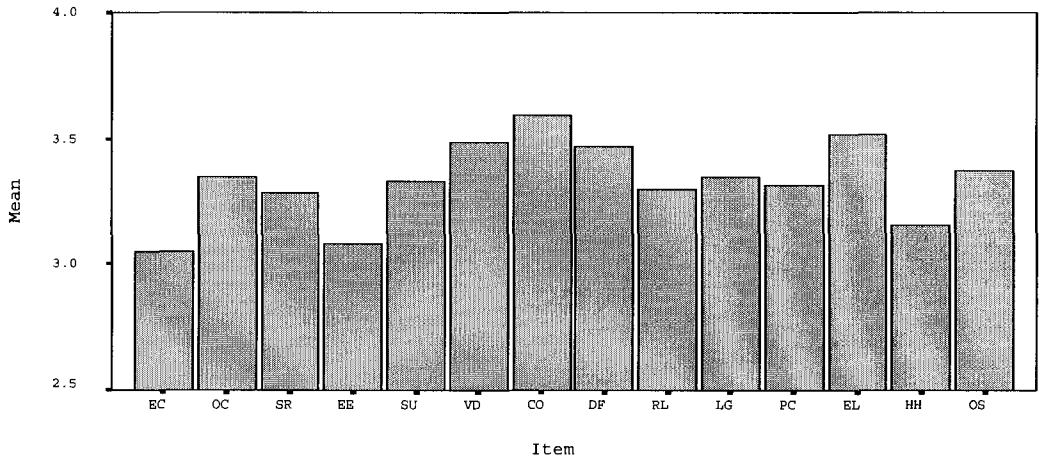

Figure 3. Mean score of each item.

An independent-samples *t* test was conducted to determine whether the experts had a different average response to the EC item than the entry-level users. The test results showed no significant difference, $t\ (62) = -1.04$, $p = .31$ (see Appendix I). The experts ($M_{exp} = 2.96$, $SD_{exp} = .60$) on the average responded no differently than the entry-level users ($M_{elu} = 3.11$, $SD_{elu} = .45$).

E-commerce capability (OC). This item was designed to identify whether the designed estimating system is more

useful for online print estimating than other systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the OC item than the entry-level users. The test results showed no significant difference, $t\ (62) = 1.89$, $p = .07$ (see Appendix I). The expert users ($M_{exp} = 3.50$, $SD_{exp} = .58$) on the average responded no differently than the entry-level users ($M_{elu} = 3.24$, $SD_{elu} = .49$).

System reliability (SR). This item was designed to identify whether the designed estimating system is more reliable at print estimating than other systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the SR item than the entry-level users. The test results showed no significant difference, $t\ (62) = -1.44$, $p = .16$ (see Appendix I). The expert users ($M_{exp} = 3.15$, $SD_{exp} = .61$) on the average responded no differently than the entry-level users ($M_{elu} = 3.37$, $SD_{elu} = .54$).

Estimating efficiency (EE). This item was designed to identify whether the estimating speed of the designed PDF print estimating system is more efficient than other systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the

EE item than the entry-level users. The test results showed no significant difference, $t\ (62) = 1.07$, $p = .29$ (see Appendix I). The experts ($M_{exp} = 2.96$, $SD_{exp} = .82$) on the average responded no differently than the entry-level users ($M_{elu} = 3.16$, $SD_{elu} = .55$).

System updating (SU). This item was designed to identify whether the system updating capability of the designed PDF print estimating system is more convenient than other systems. An independent-samples t test was conducted to determine whether the experts had a different average response to the SU item than the entry-level users. The test results did not show a significant difference, $t\ (62) = .65$, $p = .52$ (see Appendix I). The expert users ($M_{exp} = 3.38$, $SD_{exp} = .64$) on the average responded no differently than the entry-level users ($M_{elu} = 3.29$, $SD_{elu} = .46$).

Section 2 suggestions and comments. Section 2 was designed to compare the capabilities of the designed PDF print estimating system to commercial systems. An independent-samples t test was conducted to determine whether the experts had different average responses to Section 2 than the entry-level users. The test results showed no significant difference, $t\ (62) = -.39$, $p = .70$ (see Appendix I). The expert users ($M_{exp} = 3.19$, $SD_{exp} = .41$) on the

average responded no differently than the entry-level users (M_{elu} = 3.23, SD_{elu} = .36).

Most participants agreed that the designed system has sufficient capabilities. They thought it was compatible, flexible, easy to update, reliable, and capable of handling various scenarios. The online and cross-computer platform capabilities were deemed useful for the current trading environment.

On the other hand, some participants thought the system update could be made smoother by allowing users to import and export information. Another shortcoming was the file size of the designed system. It was too big to efficiently download for online estimating. Connecting the designed system with a database system for instant exchange and retrieval of information would improve online capability. Two print estimators suggested integrating the designed system with accounting and inventory systems. Another expert recommended placing more diagrams and popup windows in the designed system to provide for better interaction and estimating operations.

Section 3: Layout and Design

Section 3 consisted of six quantitative questions and one qualitative question about the designed system's layout

and design. Following are analyses of each item using independent-samples *t* tests and suggestions and comments from section 3.

Visual design (VD). This item was designed to identify whether the designed estimating system has clearer visual design than commercial systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the VD item than the entry-level users. The test results showed no significant difference, $t\ (62) = .61$, $p = .55$ (see Appendix I). The expert users ($M_{exp} = 3.54$, $SD_{exp} = .58$) on the average did not respond differently than the entry-level users ($M_{elu} = 3.45$, $SD_{elu} = .60$).

Content organization (CO). This item was designed to identify whether the designed PDF print estimating system is more clearly organized than commercial systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the CO item than the entry-level users. The test results showed no significant difference, $t\ (62) = 1.23$, $p = .23$ (see Appendix I). The experts ($M_{exp} = 3.69$, $SD_{exp} = .55$) on the average responded no differently than the entry-level users ($M_{elu} = 3.53$, $SD_{elu} = .51$).

Design flow (DF). This item was designed to identify whether the designed PDF print estimating system's design flow is smoother than commercial systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the DF item than the entry-level users. The test results showed no significant difference, $t\ (62) = .35$, $p = .73$ (see Appendix I). The expert users ($M_{exp} = 3.50$, $SD_{exp} = .65$) on the average responded no differently than the entry-level users ($M_{elu} = 3.45$, $SD_{elu} = .50$).

Readability level (RL). This item was designed to identify whether the monitor text of the designed print estimating system is easier to read than commercial systems. An independent-samples *t* test was conducted to determine whether the expert users had a different average response to the RL item than the entry-level users. The test results show a significant difference, $t\ (62) = -2.03$, $p = .05$ (see Appendix I). The experts ($M_{exp} = 3.12$, $SD_{exp} = .59$) on the average responded with lower agreement than the entry-level users ($M_{elu} = 3.42$, $SD_{elu} = .60$). Figure 4 is an error bar graph that shows the means and the standard deviations of the RL item.

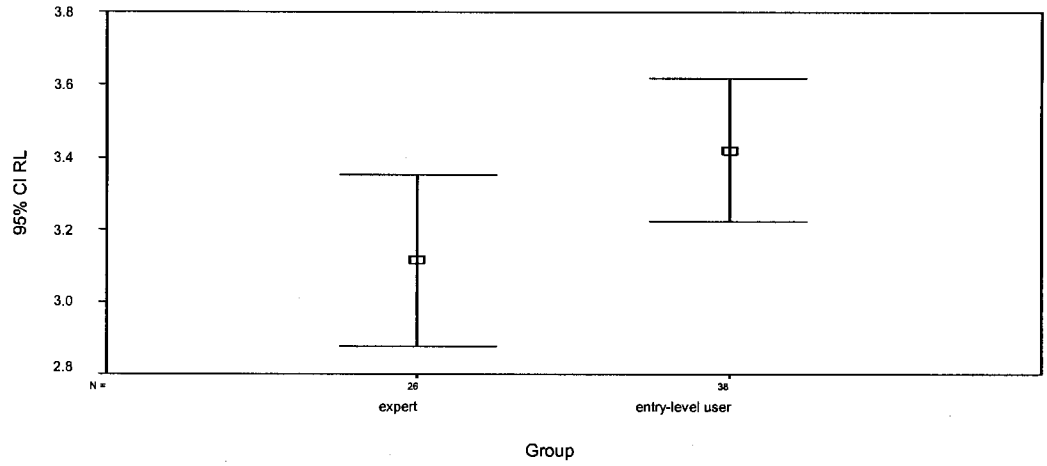

Figure 4. Error bars for the readability level for each user group. The bars show two standard deviations above and below the means.

Language (LG). This item was designed to identify whether the sentences and terms used in the designed system are easier to understand than commercial systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the LG item than the entry-level users. The test results showed no significant difference, $t\ (62) = -.77$, $p = .44$ (see Appendix I). The expert users ($M_{exp} = 3.27$, $SD_{exp} = .67$) on the average responded no differently than the entry-level users ($M_{elu} = 3.39$, $SD_{elu} = .59$).

Printout consistency usage (PC). This item was designed to identify whether the printout consistency feature of the designed system is beneficial when estimating. An independent-samples *t* test was conducted to determine

whether the experts had a different average response to the PC item than the entry-level users. The test results showed no significant difference, $t\ (62) = .84$, $p = .41$ (see Appendix I). The experts ($M_{exp} = 3.38$, $SD_{exp} = .64$) on the average responded no differently than the entry-level users ($M_{elu} = 3.26$, $SD_{elu} = .45$).

Section 3 suggestions and comments. The purpose of Section 3 was to compare the layout and design of the designed PDF print estimating system to commercial systems. An independent-samples t test was conducted to determine whether the experts had different average responses to Section 3 than the entry-level users. The test results showed no significant difference, $t\ (62) < .001$, $p = 1.0$ (see Appendix I). The experts ($M_{exp} = 3.42$, $SD_{exp} = .44$) on the average responded no differently than the entry-level users ($M_{elu} = 3.42$, $SD_{elu} = .44$).

Most participants agreed that the new system's layout and design and one-page worksheet format is well organized. They thought it was easy to follow and track because the designed print estimating system followed the step-by-step print production procedures.

On the other hand, some participants, particularly experts, thought the layout was crowded and the readability

needed improving. Some areas of the worksheet module in the designed system were too dark to read. Finally they suggested that the font size be bigger to provide for easier readability.

Section 4: Learnability

Section 4 consisted of two quantitative questions and one qualitative about the learnability of the designed system. Following are analyses of each item using independent-samples *t* tests and suggestions and comments from Section 4.

Ease of learning (EL). This item was designed to identify whether the designed PDF print estimating system is easier to learn than commercial systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the EL item than the entry-level users. The test results showed a significant difference, $t\ (62) = 2.9$, $p = .005$ (see Appendix I). The experts ($M_{exp} = 3.73$, $SD_{exp} = .45$) on the average responded with higher agreement than the entry-level users ($M_{elu} = 3.37$, $SD_{elu} = .54$). Figure 5 is an error bar graph that shows the means and the standard deviations of the ease of learning item.

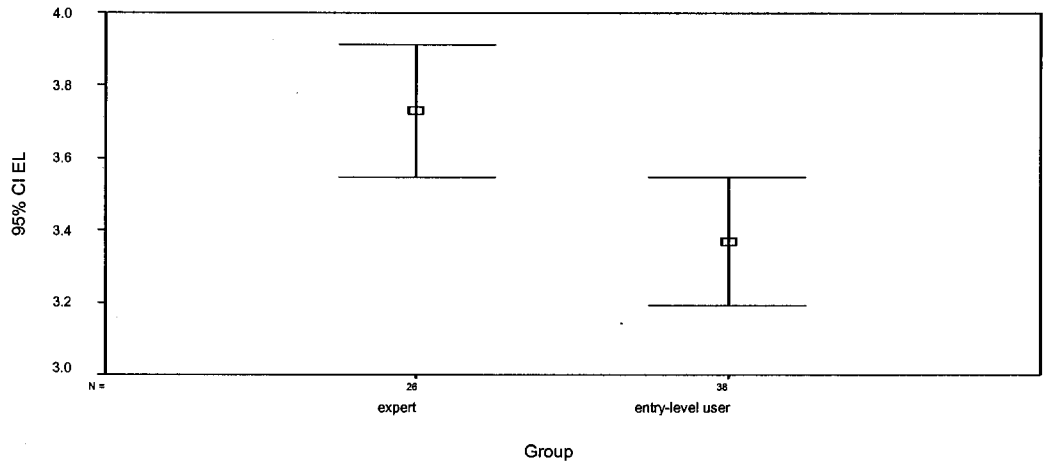

Figure 5. Error bars for ease of learning for each user group.

PDF Hot Help (HH). This item was designed to identify whether the designed estimating system provides better assistance than commercial systems. An independent-samples *t* test was conducted to determine whether the expert users had a different average response to the HH item than the entry-level users. The test results showed no significant difference, $t\ (62) = -.02$, $p = .98$ (see Appendix I). The expert users ($M_{exp} = 3.15$, $SD_{exp} = .83$) on the average did not respond differently than the entry-level users ($M_{elu} = 3.16$, $SD_{elu} = .49$).

Section 4 suggestions and comments. Section 4 was designed to compare the learnability of the PDF print estimating system to commercial systems. An independent-samples *t* test was conducted to determine whether the experts

had different average responses to Section 4 than the entry-level users. The test results showed no significant difference, $t\ (62) = 1.54$, $p = .13$ (see Appendix I). The expert users ($M_{exp} = 3.44$, $SD_{exp} = .45$) on the average did not respond differently than the entry-level users ($M_{elu} = 3.26$, $SD_{elu} = .46$).

Most participants agreed that the designed PDF print system was easy to learn. They thought it was easy for inexperienced users to learn, and easy for experienced users to transition to. The fact that system's design directly corresponds to the print production process facilitated ease of learning. Expert users rated the ease of learning the designed print estimating system significantly higher than entry-level users. On the other hand, some participants suggested that the designed system may provide dialog boxes or windows for assistance and an animation tutorial for learning.

Section 5: Overall Satisfaction

Section 5 consisted of one quantitative question and one qualitative question evaluating the overall satisfaction of the designed system. Following are the analysis using the independent-sample t test and suggestions and comments from Section 5.

Overall satisfaction (OS). This item was designed to identify whether the designed estimating system provides stronger overall satisfaction than commercial systems. An independent-samples *t* test was conducted to determine whether the experts had a different average response to the OS item than the entry-level users. The test results showed no significant difference, $t\ (62) = -.37$, $p = .71$ (see Appendix I). The experts ($M_{exp} = 3.35$, $SD_{exp} = .49$) on the average responded no differently than the entry-level users ($M_{elu} = 3.39$, $SD_{elu} = .55$).

Section 5 suggestions and comments. Most participants had strong overall satisfaction with the designed system. They agreed that the designed system has software usability equivalent to that of commercial print estimating systems. They thought the designed system is clear and easy to use and should be valuable for online and cross-computer platform print estimating.

On the other hand, some participants suggested that the designed print estimating system provide more interactive features, have options for modifying production methods, and be more flexible in order to fit the needs of different print firms.

Factor Analysis

Factor analysis can identify underlying variables that explain the pattern of correlations within a set of observed variables. It is primarily used in data reduction to determine a small number of factors that explain most of the variance observed in a larger number of manifest variables in research.

Factor analysis was conducted using a principal components method on the 14 items of the software usability evaluation survey. Although the eigenvalue-greater-than-1 criterion suggested that there were three factors underlying the measure, the scree plot indicated two factors (see Figure 6). The two-factor solution was rotated using a varimax rotation to yield interpretable factors. The results of the two-factor solution indicate that first group of factors consists of the OC, SU, VD, CO, DF, and EL items and the second group of factors consists of the SR, EE, RL, LG, PC, HH, and OS items with a critical factor loading value of .5 (see Table 9). The first group of factors appears to measure *new features* of the designed system, while the second group of factors appears to assess *performance* of the designed system. The new features of the designed system factor accounted for 29.02% of the item variance, while the

performance of the designed system factor accounted for 28.52% of the item variance (see Appendix J).

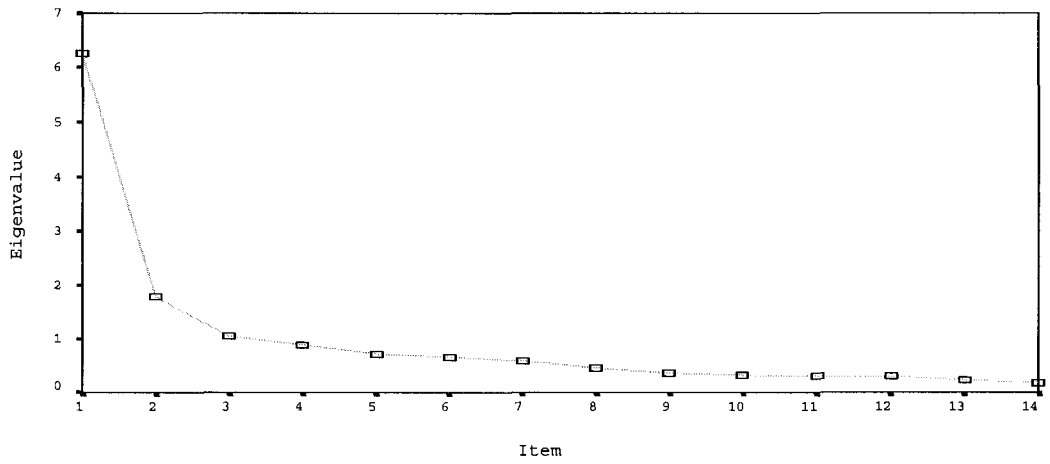

Figure 6. Scree plot of the eigenvalues.

Table 9

Factor Analysis with Varimax Rotation

Item	Component 1	Component 2
OC	*.780*	-.011
SU	*.571*	.482
VD	*.706*	.368
CO	*.788*	.241
DF	*.751*	.160
EL	*.808*	.167
RL	.354	*.692*
LG	.426	*.673*
PC	.472	*.516*
SR	.239	*.635*
EE	-.022	*.831*
HH	.029	*.773*
OS	.438	*.631*
EC	.114	.476
Eigenvalue	4.06	3.99
% of Variance	29.02	28.52

Summary

In this study, statistical methods were used to evaluate the designed PDF print estimating system. In addition, respondent comments were summarized.

The reliability of this study was examined using the split-half coefficient and the coefficient alpha methods. The test results indicated the usability survey responses have a strong reliability. In the general software usability analysis, both user groups agreed that the designed system has software usability. In the findings for the research questions, both user groups agreed that the designed system has adequate system capability and software usability equivalent to that of commercial print estimating systems. In the findings of differences between items, participants responded positively to all items. They rated especially high e-commerce capability, system updating, visual design, content organization, design flow, language, ease of learning, and overall satisfaction. In the comparison of sections and items, Section 3 and 5 were rated especially high by both user groups. Experts more highly rated the ease of learning the designed system than did entry-level users, while entry-level users responded more highly to the readability level of the designed system than did experts.

Additionally, participant suggestions and comments for further research and development were provided within each section.

In the factor analysis, variances were evaluated. The results of the usability survey responses to the designed PDF print estimating system yielded two interpretable factors—new features and performance.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter is divided into three sections: summary, conclusions, and recommendations. The study is summarized in the summary section. Conclusions are based on chapter 4. Recommendations include suggestions for future research and development of print estimating systems and software usability evaluation.

Summary

The research investigated a newly designed PDF print estimating system. PDF plays a crucial role in the printing industry, especially in document exchange and distribution. PDF has become the most useful format ever in printing, but its unlimited potential has not been fully developed and applied. In this study, PDF's usage was extended into a dynamic and interactive means of overcoming the existing problems in print estimating.

The present problems in print estimating are due to the variety of trading media, production methods, the advent of technology, and economics. An easily used and efficient print estimating system that is computer-platform independent and e-commerce capable can provide a solution for this chaos. A print estimating system in PDF can solve these problems.

The designed PDF print estimating system in this study was developed using the conventional design method. The conventional design method is based on problem needs and has a more dynamic view of the data streams. This method is suitable for situations where an existing manual system is to be replaced by a computerized system. The data flow chart used in the conventional design method provided an excellent construction blueprint. It also offered clear directions for designing the system.

Software usability survey examines computer application prototypes and provides feedback for revising and modifying the applications. Such inspection has commonly been used in the information technology industry and proven to create optimized usability. In this study, two groups of users, experts and entry-level users, evaluated the software for usability. These two groups represented professionals with different levels of print estimating system needs.

General Software Usability Analysis

The mean score of the survey responses was significantly greater than the neutral value, and both user groups revealed similar attitudes towards the designed system. Therefore, final users may agree that the designed PDF print estimating system has software usability.

Findings for the Research Questions

The system capability analysis tends to indicate that the designed system has software usability. The analysis of Research Question 1 revealed that the designed system has estimation capabilities for manual, computer, and online print estimating. The analysis of Research Question 2 indicated that the designed system has sufficient print estimating capabilities and is capable of performing correct estimations for a variety of print orders. The analysis of Research Question 3 indicated that the designed system may provide sufficient estimating capabilities for both experts and entry-level users. The analysis of Research Question 4 indicated that users may find the software usability of the designed print estimating system equal to that of commercial systems

Findings of Differences Between Items

Participants had slightly different responses to the 14 survey items, but their general responses were that the designed system has software usability. Final users may find the system's e-commerce capability, system updating, visual design, content organization, design flow, language, ease of learning and overall satisfaction items particularly satisfying.

Comparison of Sections and Items

Survey participants responded differently to each section of the survey. In comparing the section responses, analysis showed that users responded most favorably to Section 3, layout and design, and Section 5, overall satisfaction.

The comparison of sections and items revealed results similar to those in the analysis of the research questions. Both experts and entry-level users agreed that the designed system has software usability. The two levels of users had differing degrees of agreement to Section 2 and 5 and also to the specific items of readability level and ease of learning. Entry-level users rated readability level higher than other items while the experts rated ease of learning higher. In terms of the readability level, perhaps entry-level users, who tend to be younger, are more aware of such features because they are more computer-savvy. Meanwhile, expert users, those who had more print estimating system experience, indicated that the designed system is much easier for inexperienced users to learn than commercial systems. This may be because the system was designed from the viewpoint of the printer rather that of the software engineer (see Table 10).

Table 10

Means of the Items of Software Usability Survey Scores

Section and Item		M_{exp}	M_{elu}	P
Section 2		3.19	3.23	.70
	EC	2.96	3.11	.31
	OC	3.50	3.24	.07
	SR	3.15	3.37	.16
	EE	2.96	3.16	.29
	SU	3.38	3.29	.52
Section 3		3.42	3.42	1.00
	VD	3.54	3.45	.55
	CO	3.69	3.53	.23
	DF	3.50	3.45	.73
	RL	3.12	3.42	*.05*
	LG	3.27	3.39	.44
	PC	3.38	3.26	.41
Section 4		3.44	3.26	.13
	EL	3.73	3.37	*.005*
	HH	3.15	3.16	.98
Section 5		3.35	3.39	.71
	OS	3.35	3.39	.71

Factor Analysis

With the exception of the estimation capability item, all survey questionnaire items can be categorized into two factors—new features and performance. The new features factor of the designed system weighted 29.02% of the item variance and the performance factor accounted for 28.52% of the item variance. These two factors were determined to be the main focus in the designed PDF print estimating system's software usability evaluation survey.

Conclusions

Based on the analyses and findings, the following conclusions regarding the design and evaluation of the PDF print estimating system were drawn.

1. PDF is capable of providing for the needs of print estimating. This study proved that a PDF print estimating system can provide an accurate estimation capability and numerous features for print estimating. It is a compatible and useful format for print production.

2. The conventional design method is appropriate for problems like print estimating where a manual system converts to a computerized system. The conventional method provided excellent structures and directions for designing the print estimating system.

3. Because e-commerce has become their focus, both user groups indicated in their responses that there is a need for online print estimating. Such a system may prove beneficial for acquiring sales.

4. Both user groups agreed that the designed system in PDF format can eliminate operating system problems and provide more efficient usage.

5. Both user groups agreed that the designed print estimating system is easier to learn than commercial systems.

The designed system can eliminate redundant learning procedures and more efficiently helps users become accustomed to the system.

Recommendations

Recommendations were made based on limitations, delimitations, research design, and findings in this study. They are divided into two categories: recommendations for developing print estimating systems and recommendations for future research on software usability.

Recommendations for Developing Print Estimating Systems

Following are recommendations for people who are interested in developing print estimating systems.

1. PDF can continue to be used as a preferable format because it has solved many problems in print estimating and has provided a number of useful system features. Extra features and functions can be studied and implemented for print estimating.

2. The primary shortcoming of the designed PDF print estimating system is that it is difficult to modify. An easy-to-modify system can provide a greater chance for a system to succeed in the marketplace because all print estimating systems must be customized in order to fit a print firm.

3. Plug-ins may provide a solution to creating a structure-oriented and easily modified print estimating system in PDF. Plug-ins are created by the system designer and can be easily loaded by final users.

4. The designed PDF print estimating system has great potential for online estimating, but its file size is substantially bigger than a regular Webpage. Consequently, it may take longer to download or access the system. Future developers may reduce file size to increase its efficiency.

5. A general print estimating system can be Web oriented and integrated with a database, an accounting system, a tax system, and the print firm's management system.

Recommendations for Further Research on Software Usability

Following are recommendations for further research related to this study.

1. A replication of this study is recommended using a larger sample from a broader geographic area.

2. Comparing the software usability of a new system with one already being used is difficult because users have limited knowledge of the new system. A longer training and practice period is recommended in future studies to increase the validity of ratings.

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APPENDIX A

HUMAN PARTICIPANTS REVIEW LETTER

Graduate College

University of Northern Iowa

Human Participants Review Committee
122 Lang Hall
University of Northern Iowa
Cedar Falls, IA 50614
319.273.6148

Date: March 24, 2003

To: Mengtsung Tai
1412 W. 30th Street
Cedar Falls, IA 50613

From: Dr. Mary E. Losch, Chair
UNI Human Participants Review Committee
(Institutional Review Board)

Title: Design & Evaluation of a PDF Print Estimating System

Re: ID# 02-0238

Your project "Design & Evaluation of a PDF Print Estimating System," has been deemed minimal risk and determined to be exempt from further review as authorized by 45 CFR 46.101(b). For you project, the applicable exempted category referenced in 45 CFR 46.101(b) of the federal regulations is:

> Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, where: (i) information obtained is recorded in such a manner that human subjects cannot be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

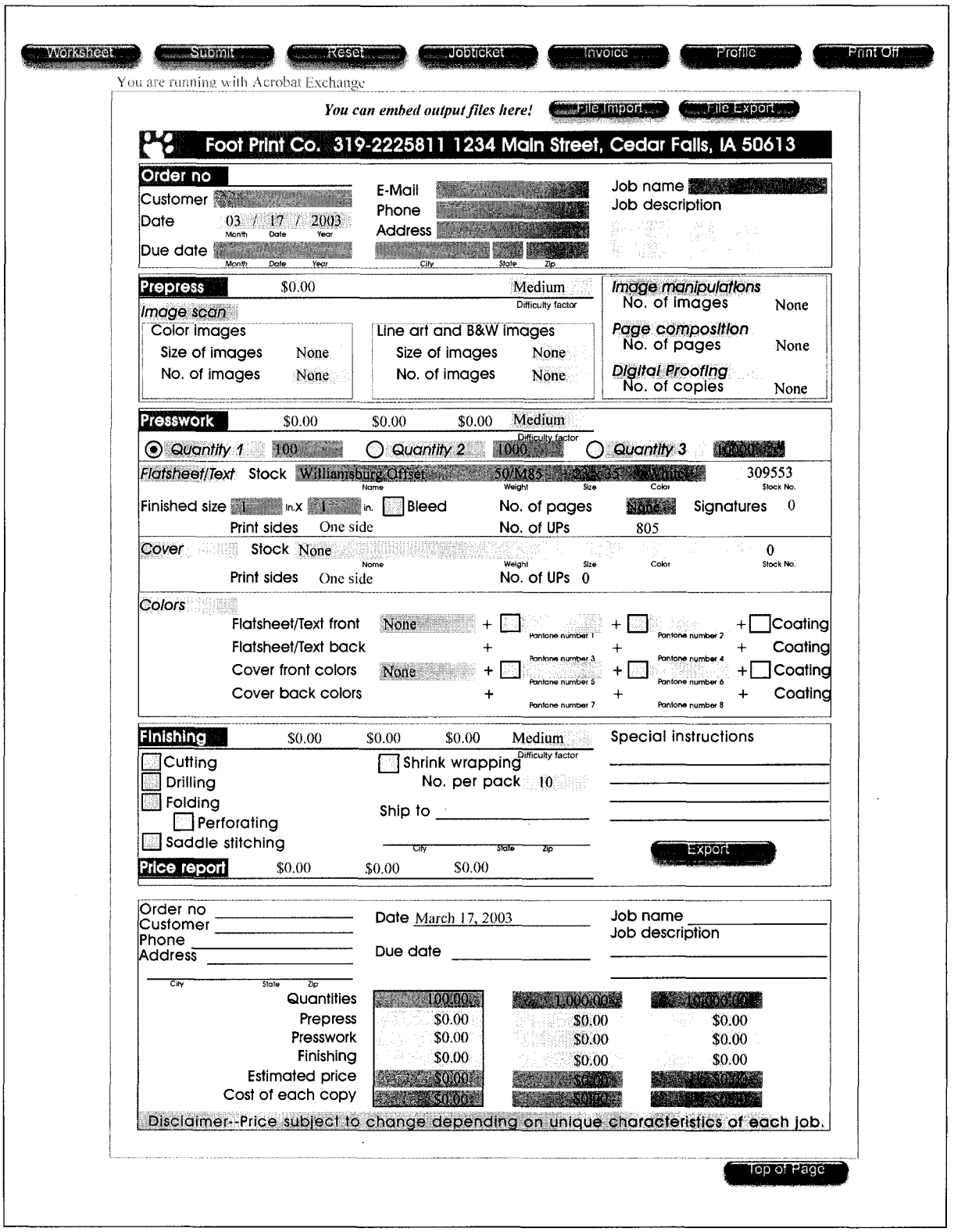
You may begin enrolling human research participants in your project. If you modify your project in a way that increases the physical, emotional, social, or legal risk to the participants or you change the targeted participants, you should notify the Human Participants Review Committee in the Graduate College Office before continuing with the research.

If you have any further questions about the Human Participants Review policies or procedures, please contact me at mary.losch@uni.edu or David Walker, the Human Participants Committee Administrator, at 319.273.6148 or email david.walker@uni.edu. Best wishes for your project success.

cc: Institutional Review Board
Charles Johnson

APPENDIX B

WORKSHEET, INVOICE, JOB TICKET, AND PROFILE OF THE DESIGNED PDF PRINT ESTIAMTING SYSTEM



Worksheet | Submit | Reset | Jobticket | Invoice | Profile | Print Off

Foot Print Co. Job ticket

General information — Estimator

Customer — Order number
Date 03 / 17 / 03 — Due date
Phone number — E-mail
Address

Job Specifications

Job name — Quantity 100 copies
Job description

Prepress operation — Prepress difficulty factor Medium

Color image scan
Sq inches per image 0 — No. of images 0
Line art images scan
Sq inches per image 0 — No. of images 0
Image manipulations — No. of images 0
Page composition — No. of pages 0
Digital proofing — No. of copies 0

Presswork operation — Presswork difficulty factor Medium

Quantity 100 copies
Text stock 309553
Finish size 1 inch x 1 inch — Bleed No
No. of text pages 0 pages — Print sides Print one side
No. of UPs 805 — No. of signatures 0
No. of colors front 0 — Pantone front 1
Pantone front 2 — Coating front No
No. of colors back 0 — Pantone back 1
Pantone back 2 — Coating back No
Cover stock None
Print sides Print one side — No. of UPs 0
No. of colors front 0 — Pantone front 1
Pantone front 2 — Coating front No
No. of colors back 0 — Pantone back 1
Pantone back 2 — Coating back No

Finishing operation — Finishing difficulty factor Medium

Cutting No — Drilling No
Folding No — Perforating No
Saddle stitching No — Shrink wrapping No
Special instruction — No. per pack 0

Ship to

Top of Page

Worksheet | Submit | Reset | Jobticket | Invoice | Profile | Print Off

Foot Print Co.
1412 West 30th Street
Cedar Falls, IA 50613
Phone: 319-2225811
E-mail: mttai@hotmail.com
www.footprintco.com

Order number

Date March 17, 2003
Due date

This estimation is valid within 10 working days of the date that is listed on this form. Please contact us if you have any questions.

Quantity	Description	Price	Unit price
100		$0.00	$0.00

Subtotal $0.00

Total $0.00

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Worksheet | Submit | Reset | Jobticket | Invoice | Profile | Print Off

Foot Print Co. Profile

1. Difficulty factors and adjustment
   - a.Low - **adjustment=** -15%
   - b.Medium - **adjustment=** 0%
   - c.High - **adjustment=** 15%
   - d.Very high - **adjustment=** 30%
2. Prepress operation
   - a. Mac *5: INVESMENT=5,400*5
     - **Image manipulation BHR=** 32.00
     - **Image manipulation minimum charge=** 16.00
     - **Page composition BHR=** 32.00
     - **Page composition minimum charge=** 22.00
   - b. PC *4: INVESMENT=4,400*4
   - c.Networking and server *1: INVESMENT = 12,000
   - d. RIP *1 (ColorQuick RIP): INVESMENT=16,000
   - e.Scanner
     - i.Drum scanner *1 (CreoScitex, Renaissance II Plus Copydot): INVESMENT=124,500
       - **Cost per S.Q. inch=** 0.50
       - **Minimum charge=** 16.00
     - ii.Flatbed scanner *1 (Linotype-Hell Topaz): INVESMENT=13,200
       - **Cost per S.Q. inch=** 0.20
       - **Minimum charge=** 22.00
   - f.Platesetter *1 (CreoScitex Trendsetter 3244+): INVESMENT=195,000
   - g. Platesetter server *1(CreoScitex Server 5000-2 CPUs): INVESMENT=45,000
     - **CTP system BHR=** 60.00
     - **CTP system processing rate (plates/per hour)=** 12.00
     - **Plate cost (per plate)=** 16.00
   - h. Proofer *1 (Imation Rainbow 4700XL): INVESMENT=59,900
     - **Digital proofing BHR=** 20.00
     - **Digital proofing minimum charge=** 20.00
     - **Digital proofing material cost (per copy)=** 12.00
3. Offset press *1 (Mitsubishi 3F 6-Color With Tower Coater & Extended Delivery): BHR=365.14, INVESMENT=2,300,000 plus support equipment 50,000
   - **Pressrun BHR=** 450.00
   - **Press make ready time=** 1.00
   - **Press wash-up time=** 1.00
   - **Press run rate (page/per hour)=** 12,000.00

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Worksheet | Submit | Reset | Jobticket | Invoice | Profile | Print Off

4.Paper profile

Text stock

Springhill Opaque Offset Colors, 50 lb/M85 lb, 23 x 35

883220 Green, price per 1000 sheets= 97.46

883240 Ivory, price per 1000 sheets= 97.46

883280 Pink, price per 1000 sheets= 97.46

Springhill Opaque Colors, 60 lb/ M102 lb, 23 x 35

883440 Blue, price per 1000 sheets= 114.57

883450 Green, price per 1000 sheets= 114.57

883510 Pink, price per 1000 sheets= 114.57

Springhill Opaque Colors, 70 lb/M119 lb, 23x35

883040 Blue, price per 1000 sheets= 133.66

889350 Cream, price per 1000 sheets= 133.66

Williamsburg Offset White, 50 lb/M85 lb, 23x35

309553 White, price per 1000 sheets= 68.29

Williamsburg Offset White, 50lb/M100 lb, 25x38

309563 White, price per 1000 sheets= 80.34

Williamsburg Offset White, 60lb/M102 lb, 23x35

309633 White, price per 1000 sheets= 93.60

Williamsburg Offset White, 60lb/M120 lb, 25x38

309643 White, price per 1000 sheets= 93.60

Williamsburg Offset White, 70lb/M119 lb, 23x35

309663 White, price per 1000 sheets= 79.56

Williamsburg Offset White, 70lb/M140 lb, 25x38

309673 White, price per 1000 sheets= 93.60

Cover stock

Springhill Vellum Bristol Cover Colors, 60 lb/M168 lb, 23x35

143030 Blue, price per 1000 sheets= 177.56

143040 Green, price per 1000 sheets= 177.56

143050 Pink, price per 1000 sheets= 177.56

522630 Gray, price per 1000 sheets= 177.56

Springhill Vellum Bristol Cover White, 67lb/ M168 lb, 23x35

142970 White, price per 1000 sheets= 167.08

Springhill Vellum Bristol Cover White, 67lb/M218 lb, 26x40

408740 White, price per 1000 sheets= 216.80

Springhill Vellum Bristol Cover White, 80lb/M201 lb, 23x35

884100 White, price per 1000 sheets= 199.89

5.Ink information

Ink coverage= 20%

Ink mileage= 320,000.00

Ink cost (per pound)= 6.50

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Worksheet | Submit | Reset | Jobticket | Invoice | Profile | Print Off

6.Finishing

a.Cutter *1 (MAN Roland, Wohlenberg Paper Cutter Model 137P): INVESMENT=97,000

No of pages per lift= 500.00

Cutting BHR= 72.00

b.Drill *1 (Challenge Machinery, EH-3C Multiple Spindle Drill): INVESMENT=8,012

No of pages per lift= 200.00

Drilling BHR= 60.00

c.Folder *1(MBO, B26S 4-4-4): INVESMENT=110,000

Folder make ready time= 1.00

Folder run rate(page/per hour)= 41,000.00

Folder BHR= 80.00

d.Saddle stitcher (Heidelberg USA Stahl ST-270, 6-Pocket)*1: INVESMENT=326,580

Saddle stitcher make ready time= 1.00

Saddle stitcher run rate(page/per hour)= 11,500.00

Saddle stitcher BHR= 190.00

e.Shrink wrap *1 (APS Packaging Systems, Transport System): INVESMENT=6,265

Shrink wrap rate (pack/per hour)= 600.00

Shrink wrap BHR= 46.00

f.Jogger *1 (Challenge Machinery Model 2840A Jogger): INVESMENT=3,423

g.Banding* 1 (General Graphic, Band-A Pro Bander Banding Press): INVESMENT= 395

h.Strapping *1 (Bunn, Semi-Automatic Strapping Machine): INVESMENT=1,950

7.Transportation

a.Truck *1 (Toyota TACOMA REGULAR CAB 2WD): INVESMENT=12,410

b.Fork lift *1(Toyota 7FB): INVESMENT=7,000

8.Human resource (for running 2 shifts)

a.Manager *1: 60,000

b.Production manager *1: 50,000

c.Purchaser & estimator *1: 37,500

d.Customer service representative *2: 35,000*2

e.Prepress operator *5: A.S.1=45,954, BHR1=38.50; A.S.2=78,974, BHR2=63.98

f.Press operator

i.Pressmen *2: 37,500*2

ii.Feeders *4: 20,000*4

g.Finishing

i.Cutter operator *2: 25,000*2

ii.Folder operator *2: 27,000*2

iii.Full time helper *2: 22,000*2

iv.Temporary/ part-time employees up to 10

h.Warehouse keeper (shipping, receiving, and inventory)*1: 25,000

i.Truck driver *1: 25000

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APPENDIX C

SOFTWARE USABILITY EVALUATION SURVEY QUESTIONNAIRE

PDF Print Estimating System Evaluation

Overview: This questionnaire is for evaluating a PDF print estimating system. The system is designed to be used online or offline and on different computer operating systems.
Directions: Please respond to all the items and add other suggestions at the end.

Section 1: Print Estimating System Experience

1.1 How would you rate your level of experience with print estimating systems?
___ Beginner ___ Occasional User ___ Experienced User

1.2 What print estimating system(s) do you know how to use?
1. _____ 2. _____ 3. _____

1.3 If you have used websites for estimating, which ones have you used?
1. _____ 2. _____ 3. _____

Section 2: System Capability

1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree

2.1 Estimation capability *The designed estimating system is capable for print estimating compared to other systems.*	**1**	**2**	**3**	**4**
2.2 E-commerce capability *The system is capable for online print estimating compared with other systems.*	**1**	**2**	**3**	**4**
2.3 System reliability *The system appears reliable (e.g. no problems or crashes encountered) compared with others.*	**1**	**2**	**3**	**4**
2.4 Estimating efficiency *The speed of the system for estimating is efficient compared to other systems.*	**1**	**2**	**3**	**4**
2.5 System updating *Updating of the system is convenient compared to other systems.*	**1**	**2**	**3**	**4**

2.6 Please write your comments about the **system capability**.

_____

_____

Section 3: Layout & Design

1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree

3.1 Visual design *The overall visual design of the system is clear compared with others.*	**1**	**2**	**3**	**4**
3.2 Content organization *The content of the system is organized well compared with other systems.*	**1**	**2**	**3**	**4**
3.3 Design flow *As compared with others, you rate the way the program is designed to flow from prepress to presswork and finishing when estimating is smooth.*	**1**	**2**	**3**	**4**
3.4 Readability level *The text on the monitor is easy to read compared with other systems.*	**1**	**2**	**3**	**4**
3.5 Language *The text (sentences and terms) of the system is easy to understand compared to other systems.*	**1**	**2**	**3**	**4**
3.6 Printout consistency usage *The screen layout matches the printout is beneficial when estimating.*	**1**	**2**	**3**	**4**

3.7 Please write your comments about the **layout & design**.

_____

_____

Section 4: Learnability *1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree*

4.1 Ease of learning **1 2 3 4**

The system is easier to learn compared to other systems.

4.2 PDF Hot Help **1 2 3 4**

Hot Help is useful compared to other help systems.

4.3 Please write your comments about the **learnability**.

_____

_____

Section 5: Overall Satisfaction *1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree*

5.1 Overall satisfaction **1 2 3 4**

You are overall satisfied with this system for estimating compared to others.

5.2 Please write your comments about the **overall satisfaction**.

_____

_____

Section 6: Do you have any other comments that will provide information on evaluating this system?

_____

_____

_____

_____

_____

Again, thank you for your patient and valuable time.

APPENDIX D

RESULTS OF THE SURVEY RESPONSES

THE EXPERT RESPONSES

Item	The Expert Responses			
	Strongly Disagree	Disagree	Agree	Strongly Agree
EC	0	5	17	4
OC	0	1	11	14
SR	0	3	16	7
EE	1	6	12	7
SU	0	2	12	12
VD	0	1	10	15
CO	0	1	6	19
DF	0	2	9	15
RL	0	3	17	6
LG	0	3	13	10
PC	0	2	12	12
EL	0	0	7	19
HH	0	7	8	11
OS	0	0	17	9

THE ENTRY-LEVEL USER RESPONSES

Item	The Entry-Level User Responses			
	Strongly Disagree	Disagree	Agree	Strongly Agree
EC	0	2	30	6
OC	0	1	27	10
SR	0	1	22	15
EE	0	3	26	9
SU	0	0	27	11
VD	0	2	17	19
CO	0	0	18	20
DF	0	0	21	17
RL	0	2	18	18
LG	0	2	19	17
PC	0	0	28	10
EL	0	1	22	15
HH	0	2	28	8
OS	0	1	21	16

APPENDIX E

RESULTS OF THE SPLIT-HALF COEFFICIENT AND THE COEFFICIENT ALPHA

Reliability Test Using Split-Half Coefficient Estimates

****** Method 2 (covariance matrix) will be used for this analysis ******

R E L I A B I L I T Y A N A L Y S I S - S C A L E (S P L I T)

		Mean	Std Dev	Cases
1.	EC	3.0469	.5173	64.0
2.	SR	3.2813	.5765	64.0
3.	SU	3.3281	.5361	64.0
4.	CO	3.5938	.5261	64.0
5.	RL	3.2969	.6089	64.0
6.	PC	3.3125	.5308	64.0
7.	HH	3.1563	.6478	64.0
8.	OC	3.3438	.5410	64.0
9.	EE	3.0781	.6739	64.0
10.	VD	3.4844	.5907	64.0
11.	DF	3.4688	.5626	64.0
12.	LG	3.3438	.6228	64.0
13.	EL	3.5156	.5343	64.0
14.	OS	3.3750	.5195	64.0

Correlation Matrix

	EC	SR	SU	CO	RL
EC	1.0000				
SR	.2212	1.0000			
SU	.3443	.4157	1.0000		
CO	.1877	.3304	.4801	1.0000	
RL	.2575	.5723	.4262	.4815	1.0000
PC	.3505	.4344	.4706	.5187	.4451
HH	.1673	.3905	.3985	.1426	.4841
OC	.2818	.1431	.4806	.4427	.3117
EE	.3991	.4328	.4551	.2253	.4455
VD	.1842	.3394	.4926	.6943	.5206
DF	.0324	.4191	.5345	.6000	.3287
LG	.3433	.4338	.4650	.4814	.5637
EL	.1409	.2432	.5082	.5876	.3026
OS	.2880	.3843	.4631	.4501	.6461

	PC	HH	OC	EE	VD
PC	1.0000				
HH	.4559	1.0000			
OC	.3939	.0255	1.0000		
EE	.3300	.5534	-.0313	1.0000	
VD	.3702	.2968	.4144	.3022	1.0000
DF	.4585	.2314	.4531	.1531	.5000
LG	.4861	.4549	.3033	.5401	.5757
EL	.3743	.2221	.5852	.1949	.6043
OS	.4318	.4835	.3248	.4138	.5884

R E L I A B I L I T Y A N A L Y S I S - S C A L E (S P L I T)

Correlation Matrix

	DF	LG	EL	OS
DF	1.0000			
LG	.3483	1.0000		
EL	.5562	.5083	1.0000	
OS	.3123	.6255	.4933	1.0000

N of Cases = 64.0

Statistics for	Mean	Variance	Std Dev	N of Variables
Part 1	23.0156	7.3172	2.7050	7
Part 2	23.6094	8.1148	2.8487	7
Scale	46.6250	27.9524	5.2870	14

Reliability Coefficients 14 items

Correlation between forms = .8124 Equal-length Spearman-Brown = .8965

Guttman Split-half = .8958 Unequal-length Spearman-Brown = .8965

Alpha for part 1 = .8101 Alpha for part 2 = .8280

7 items in part 1 7 items in part 2

Reliability Test Using Coefficient Alpha

****** Method 2 (covariance matrix) will be used for this analysis ******

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

		Mean	Std Dev	Cases
1.	EC	3.0469	.5173	64.0
2.	OC	3.3438	.5410	64.0
3.	SR	3.2813	.5765	64.0
4.	EE	3.0781	.6739	64.0
5.	SU	3.3281	.5361	64.0
6.	VD	3.4844	.5907	64.0
7.	CO	3.5938	.5261	64.0
8.	DF	3.4688	.5626	64.0
9.	RL	3.2969	.6089	64.0
10.	LG	3.3438	.6228	64.0
11.	PC	3.3125	.5308	64.0
12.	EL	3.5156	.5343	64.0
13.	HH	3.1563	.6478	64.0
14.	OS	3.3750	.5195	64.0

Correlation Matrix

	EC	OC	SR	EE	SU
EC	1.0000				
OC	.2818	1.0000			
SR	.2212	.1431	1.0000		
EE	.3991	-.0313	.4328	1.0000	
SU	.3443	.4806	.4157	.4551	1.0000
VD	.1842	.4144	.3394	.3022	.4926
CO	.1877	.4427	.3304	.2253	.4801
DF	.0324	.4531	.4191	.1531	.5345
RL	.2575	.3117	.5723	.4455	.4262
LG	.3433	.3033	.4338	.5401	.4650
PC	.3505	.3939	.4344	.3300	.4706
EL	.1409	.5852	.2432	.1949	.5082
HH	.1673	.0255	.3905	.5534	.3985
OS	.2880	.3248	.3843	.4138	.4631

	VD	CO	DF	RL	LG
VD	1.0000				
CO	.6943	1.0000			
DF	.5000	.6000	1.0000		
RL	.5206	.4815	.3287	1.0000	
LG	.5757	.4814	.3483	.5637	1.0000
PC	.3702	.5187	.4585	.4451	.4861
EL	.6043	.5876	.5562	.3026	.5083
HH	.2968	.1426	.2314	.4841	.4549

R E L I A B I L I T Y A N A L Y S I S - S C A L E (A L P H A)

Correlation Matrix

	PC	EL	HH	OS
PC	1.0000			
EL	.3743	1.0000		
HH	.4559	.2221	1.0000	
OS	.4318	.4933	.4835	1.0000

N of Cases = 64.0

Statistics for Scale	Mean	Variance	Std Dev	N of Variables
	46.6250	27.9524	5.2870	14

Reliability Coefficients 14 items

Alpha = .9000 Standardized item alpha = .9013

APPENDIX F

STATISTICS OF THE GENERAL SOFTWARE USABILITY

RESULTS OF GENERAL SOFTWARE USABILITY

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
MEAN	64	3.3304	.3776	.0472

One-Sample Test

	Test Value = 2.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
MEAN	17.590	63	.000	.8304	.7360	.9247

RESULTS OF GENERAL SOFTWARE USABILITY

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
MEAN	expert	26	3.3352	.3713	7.282E-02
	entry-level user	38	3.3271	.3868	6.275E-02

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MEAN	Equal variances assumed	.863	.356	.084	62	.934	.0081	.0969	-.186	.2018
	Equal variances not assumed			.084	55.31	.933	.0081	.0961	-.185	.2007

APPENDIX G

STATISTICS OF THE FINDINGS FOR THE RESEARCH QUESTIONS

RESULTS OF RESEARCH QUESTION 1

RESULTS OF SECTION 2

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
SEC2	64	3.2156	.3826	5.E-02

One-Sample Test

	Test Value = 2.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
SEC2	14.962	63	.000	.7156	.6200	.8112

RESULTS OF RESEARCH QUESTION 2

RESULTS OF SECTION 2 EXPERT RESPONSES

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
SEC2	26	3.1923	.4137	.0811

One-Sample Test

	Test Value = 2.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
SEC2	8.533	25	.000	.6923	.5252	.8594

RESULTS OF SECTION 2 ENTRY-LEVEL USER RESPONSES

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
SEC2	38	3.2316	.3647	6.E-02

One-Sample Test

	Test Value = 2.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
SEC2	12.365	37	.000	.7316	.6117	.8515

RESULTS OF RESEARCH QUESTION 3

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
MEAN	64	3.3304	.3776	5.E-02

One-Sample Test

	Test Value = 3.0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
MEAN	6.998	63	.000	.3304	.2360	.4247

RESULTS OF RESEARCH QUESTION 4

RESULTS OF SECTION 5 RESPONSES

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
SEC5	64	3.3750	.5195	6.E-02

One-Sample Test

	Test Value = 2.5					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
SEC5	13.475	63	.000	.8750	.7452	1.0048

APPENDIX H

STATISTICS OF THE FINDINGS OF DIFFERENCES BETWEEN ITEMS

RESULTS OF FINDINGS OF DIFFERENCES BETWEEN ITEMS

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
ITEM	Pillai's Trace	.467	3.44[a]	13.00	51.00	.001	.467
	Wilks' Lambda	.533	3.44[a]	13.00	51.00	.001	.467
	Hotelling's Trace	.878	3.44[a]	13.00	51.00	.001	.467
	Roy's Largest Root	.878	3.44[a]	13.00	51.00	.001	.467

a. Exact statistic

b.
Design: Intercept
Within Subjects Design: ITEM

RESULTS OF PAIRED-SAMPLES CORRELATIONS OF ITEMS

		N	Correlation	Sig.
Pair 1	EC & OC	64	.282	.0240653246
Pair 2	EC & SR	64	.221	.0789703885
Pair 3	EC & EE	64	.399	.0010870382
Pair 4	EC & SU	64	.344	.0053421837
Pair 5	EC & VD	64	.184	.1450267958
Pair 6	EC & CO	64	.188	.1374246373
Pair 7	EC & DF	64	.032	.7994627385
Pair 8	EC & RL	64	.257	.0399871430
Pair 9	EC & LG	64	.343	.0054789954
Pair 10	EC & PC	64	.350	.0045252631
Pair 11	EC & EL	64	.141	.2668350325
Pair 12	EC & HH	64	.167	.1864839566
Pair 13	EC & OS	64	.288	.0210341889
Pair 14	OC & SR	64	.143	.2591424812
Pair 15	OC & EE	64	-.031	.8060813808
Pair 16	OC & SU	64	.481	.0000584302
Pair 17	OC & VD	64	.414	.0006626371
Pair 18	OC & CO	64	.443	.0002494251
Pair 19	OC & DF	64	.453	.0001700708
Pair 20	OC & RL	64	.312	.0121667881
Pair 21	OC & LG	64	.303	.0148481621
Pair 22	OC & PC	64	.394	.0012821505
Pair 23	OC & EL	64	.585	.0000003806
Pair 24	OC & HH	64	.025	.8416077964
Pair 25	OC & OS	64	.325	.0088330691
Pair 26	SR & EE	64	.433	.0003539006
Pair 27	SR & SU	64	.416	.0006362410
Pair 28	SR & VD	64	.339	.0060794022
Pair 29	SR & CO	64	.330	.0076723887
Pair 30	SR & DF	64	.419	.0005673944
Pair 31	SR & RL	64	.572	.0000007812

Pair 32	SR & LG	64	.434	.0003422548
Pair 33	SR & PC	64	.434	.0003347058
Pair 34	SR & EL	64	.243	.0528406162
Pair 35	SR & HH	64	.391	.0014220175
Pair 36	SR & OS	64	.384	.0017185689
Pair 37	EE & SU	64	.455	.0001577707
Pair 38	EE & VD	64	.302	.0152354574
Pair 39	EE & CO	64	.225	.0735147164
Pair 40	EE & DF	64	.153	.2271570142
Pair 41	EE & RL	64	.445	.0002255588
Pair 42	EE & LG	64	.540	.0000041038
Pair 43	EE & PC	64	.330	.0077354538
Pair 44	EE & EL	64	.195	.1226739192
Pair 45	EE & HH	64	.553	.0000021160
Pair 46	EE & OS	64	.414	.0006774045
Pair 47	SU & VD	64	.493	.0000355765
Pair 48	SU & CO	64	.480	.0000595810
Pair 49	SU & DF	64	.534	.0000053872
Pair 50	SU & RL	64	.426	.0004458265
Pair 51	SU & LG	64	.465	.0001084581
Pair 52	SU & PC	64	.471	.0000869878
Pair 53	SU & EL	64	.508	.0000180896
Pair 54	SU & HH	64	.398	.0011098080
Pair 55	SU & OS	64	.463	.0001166503
Pair 56	VD & CO	64	.694	.0000000001
Pair 57	VD & DF	64	.500	.0000258703
Pair 58	VD & RL	64	.521	.0000103675
Pair 59	VD & LG	64	.576	.0000006482
Pair 60	VD & PC	64	.370	.0026056720
Pair 61	VD & EL	64	.604	.0000001231
Pair 62	VD & HH	64	.297	.0172259560
Pair 63	VD & OS	64	.588	.0000003169
Pair 64	CO & DF	64	.600	.0000001597

Pair 65	CO & RL	64	.482	.0000561496
Pair 66	CO & LG	64	.481	.0000564826
Pair 67	CO & PC	64	.519	.0000113108
Pair 68	CO & EL	64	.588	.0000003312
Pair 69	CO & HH	64	.143	.2608669207
Pair 70	CO & OS	64	.450	.0001900210
Pair 71	DF & RL	64	.329	.0080024665
Pair 72	DF & LG	64	.348	.0048000345
Pair 73	DF & PC	64	.458	.0001389765
Pair 74	DF & EL	64	.556	.0000018342
Pair 75	DF & HH	64	.231	.0658081504
Pair 76	DF & OS	64	.312	.0119858677
Pair 77	RL & LG	64	.564	.0000012358
Pair 78	RL & PC	64	.445	.0002288188
Pair 79	RL & EL	64	.303	.0150682432
Pair 80	RL & HH	64	.484	.0000505022
Pair 81	RL & OS	64	.646	.0000000070
Pair 82	LG & PC	64	.486	.0000464949
Pair 83	LG & EL	64	.508	.0000180245
Pair 84	LG & HH	64	.455	.0001591062
Pair 85	LG & OS	64	.626	.0000000311
Pair 86	PC & EL	64	.374	.0023117466
Pair 87	PC & HH	64	.456	.0001534782
Pair 88	PC & OS	64	.432	.0003676600
Pair 89	EL & HH	64	.222	.0776987444
Pair 90	EL & OS	64	.493	.0000345277
Pair 91	HH & OS	64	.483	.0000518599

APPENDIX I

STATISTICS OF THE COMPARISON OF SECTIONS AND ITEMS

RESULTS OF COMPARISON OF SECTIONS AND ITEMS

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.
SECTION	Pillai's Trace	.304	8.898[a]	3.000	61.000	.000
	Wilks' Lambda	.696	8.898[a]	3.000	61.000	.000
	Hotelling's Trace	.438	8.898[a]	3.000	61.000	.000
	Roy's Largest Root	.438	8.898[a]	3.000	61.000	.000

a. Exact statistic

b.
Design: Intercept
Within Subjects Design: SECTION

RESULTS OF PAIRED SAMPLES CORRELATIONS OF SECTIONS

		N	Correlation	Sig.
Pair 1	SEC2 & SEC3	64	.726	.0000000000
Pair 2	SEC2 & SEC4	64	.614	.0000000648
Pair 3	SEC2 & SEC5	64	.561	.0000014272
Pair 4	SEC3 & SEC4	64	.692	.0000000001
Pair 5	SEC3 & SEC5	64	.678	.0000000004
Pair 6	SEC4 & SEC5	64	.622	.0000000386

RESULTS OF ESTIMATION CAPABILITY RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
EC	expert	26	2.96	.60	.12
	entry-level user	38	3.11	.45	.07

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EC	Equal variances assumed	.733	.395	-1.093	62	.278	-.14	.13	-.41	.12
	Equal variances not assumed			-1.038	43.8	.305	-.14	.14	-.42	.14

RESULTS OF E-COMMERCE CAPABILITY RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
OC	expert	26	3.50	.58	.11
	entry-level user	38	3.24	.49	.08

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
OC	Equal variances assumed	4.842	.032	1.954	62	.055	.26	.13	-.01	.53
	Equal variances not assumed			1.890	47.47	.065	.26	.14	-.02	.54

RESULTS OF SYSTEM RELIABILITY RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
SR	expert	26	3.15	.61	.12
	entry-level user	38	3.37	.54	.09

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SR	Equal variances assumed	.329	.568	-1.476	62	.145	-.21	.15	-.51	.08
	Equal variances not assumed			-1.442	49	.156	-.21	.15	-.51	.08

RESULTS OF ESTIMATING EFFICIENCY RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
EE	expert	26	2.96	.82	.16
	entry-level user	38	3.16	.55	.09

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EE	Equal variances assumed	2.872	.095	1.148	62	.255	-.20	.17	-.54	.15
	Equal variances not assumed			1.066	9.886	.293	-.20	.18	-.57	.18

RESULTS OF SYSTEM UPDATING RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
SU	expert	26	3.38	.64	.12
	entry-level user	38	3.29	.46	.07

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SU	Equal variances assumed	7.460	.008	.694	62	.490	1.E-01	.14	-.18	.37
	Equal variances not assumed			.654	42.34	.517	1.E-01	.15	-.20	.39

RESULTS OF SECTION 2 RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
SEC2	expert	26	3.1923	.4137	.0811
	entry-level user	38	3.2316	.3647	.0592

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEC2	Equal variances assumed	.397	.531	-.401	62	.690	-.0393	1.E-01	-.2353	.1567
	Equal variances not assumed			-.391	49.25	.697	-.0393	.1004	-.2410	.1625

RESULTS OF VISUAL DESIGN RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
VD	expert	26	3.54	.58	.11
	entry-level user	38	3.45	.60	.10

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VD	Equal variances assumed	.134	.715	.603	62	.549	9.E-02	.15	-.21	.39
	Equal variances not assumed			.607	55.06	.547	9.E-02	.15	-.21	.39

RESULTS OF CONTENT ORGANIZATION RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
CO	expert	26	3.69	.55	.11
	entry-level user	38	3.53	.51	.08

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
CO	Equal variances assumed	.993	.323	1.245	62	.218	.17	.13	-.10	.43
	Equal variances not assumed			1.226	50.88	.226	.17	.14	-.11	.44

RESULTS OF DESIGN FLOW RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
DF	expert	26	3.50	.65	.13
	entry-level user	38	3.45	.50	.08

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
DF	Equal variances assumed	3.337	.073	.365	62	.716	5.E-02	.14	-.24	.34
	Equal variances not assumed			.348	44.78	.729	5.E-02	.15	-.25	.36

RESULTS OF READABILITY LEVEL RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
RL	expert	26	3.12	.59	.12
	entry-level user	38	3.42	.60	.10

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
RL	Equal variances assumed	3.06	.085	-2.02	62	.048	-.31	.15	-.61	.00
	Equal variances not assumed			-2.03	54.49	.048	-.31	.15	-.61	.00

RESULTS OF LANGUAGE RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
LG	expert	26	3.27	.67	.13
	entry-level user	38	3.39	.59	.10

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
LG	Equal variances assumed	.084	.773	-.789	62	.433	-.13	.16	-.44	.19
	Equal variances not assumed			-.772	49.67	.444	-.13	.16	-.45	.20

RESULTS OF PRINTOUT CONSISTENCY USAGE RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
PC	expert	26	3.38	.64	.12
	entry-level user	38	3.26	.45	.07

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PC	Equal variances assumed	9.098	.004	.898	62	.373	.12	.14	-.15	.39
	Equal variances not assumed			.841	41.44	.405	.12	.14	-.17	.41

RESULTS OF SECTION 3 RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
SEC3	expert	26	3.42	.4403	.0864
	entry-level user	38	3.42	.4380	.0710

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEC3	Equal variances assumed	.958	.332	.000	62	1.000	9.E-16	.1117	-.2233	.2233
	Equal variances not assumed			.000	53.68	1.000	9.E-16	.1118	-.2242	.2242

RESULTS OF EASE OF LEARNING RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
EL	expert	26	3.73	.45	.09
	entry-level user	38	3.37	.54	.09

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EL	Equal variances assumed	4.258	.043	2.806	62	.007	.36	.13	.10	.62
	Equal variances not assumed			2.903	59.44	.005	.36	.12	.11	.61

RESULTS OF PDF HOT HELP RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
HH	expert	26	3.15	.83	.16
	entry-level user	38	3.16	.49	.08

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
HH	Equal variances assumed	15.00	.000	-.024	62	.981	.00	.17	-.34	.33
	Equal variances not assumed			-.022	37.04	.982	.00	.18	-.37	.37

RESULTS OF SECTION 4 RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
SEC4	expert	26	3.442	.4545	.0891
	entry-level user	38	3.263	.4612	.0748

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SEC4	Equal variances assumed	.187	.667	1.535	62	.130	.1791	.1167	-.054	.4124
	Equal variances not assumed			1.540	54.39	.129	.1791	.1164	-.054	.4124

RESULTS OF OVERALL SATISFACTION RESPONSES

Group Statistics

	GROUP	N	Mean	Std. Deviation	Std. Error Mean
OS	expert	26	3.35	.49	.10
	entry-level user	38	3.39	.55	.09

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
OS	Equal variances assumed	1.765	.189	-.365	62	.716	-.05	.13	-.31	.22
	Equal variances not assumed			-.373	57.85	.710	-.05	.13	-.31	.21