AN EXPLORATORY STUDY OF FACTORS THAT INFLUENCE STUDENT USER SUCCESS IN AN ACADEMIC DIGITAL LIBRARY

Faizur Rahman, B.A., M.A., MLS.

Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

December 2007

APPROVED:

Brian C. O'Connor, Committee Co-Chair
Guillermo A. Oyarce, Committee Co-Chair
Abebe Rorissa, Committee Member
Larry Sall, Committee Member
Herman L. Totten, Dean of the School of Library and Information Sciences
Sandra L. Terrell, Dean of the Robert B. Toulouse School of Graduate Studies

Rahman, Faizur, An exploratory study of factors that influence student user success in an academic digital library. Doctor of Philosophy (Information Science), December 2007, 115 pp., 20 tables, 13 illustrations, references, 56 titles.

The complex nature of digital libraries calls for appropriate models to study user success. Calls have been made to incorporate into these models factors that capture the interplay between people, organizations, and technology. In order to address this, two research questions were formulated: (1) To what extent does the comprehensive digital library user success model (DLUS), based on a combination of the EUCS and flow models, describe overall user success in a prototype digital library environment; and (2) To what extent does a combined model of DeLone & McLean's reformulated information system success model and comprehensive digital library user success model (DLUS) explain digital library user success in a prototype digital library environment? Participants were asked to complete an online survey questionnaire. A total of 160 completed and useable questionnaires were obtained. Data analyses through exploratory and confirmatory factor analyses and structural equation modeling produced results that support the two models. However, some relationships between latent variables hypothesized in the model were not confirmed. A modified version of the proposed comprehensive plus user success model in a digital library environment was tested and supported through model fit statistics. This model was recommended as a possible alternative model of user success. The dissertation also makes a number of recommendations for future research.

ACKNOWLEDGMENTS

I could not have achieved the ultimate accomplishment of writing this dissertation without the valued contribution of several individuals that I want to acknowledge for their sincere support and encouragement.

First, I would like to express my sincere gratitude to my dissertation Chair and Co-chair, Dr. Guillermo Oyarce and Dr. Brian O'Connor, for their guidance, encouragement, and patience. I also want to recognize the other members of my dissertation committee, Dr. Abebe Rorissa and Dr. Larry Sall, for their invaluable suggestions and support. My special thanks go to Dr. Rorissa, who spent countless hours trying to improve various drafts of this dissertation. The students at the University of Texas at Dallas made this research possible through their participation and I thank them for that.

My heartiest thanks go to my motherland, Bangladesh, for providing me with free quality education as well as my second motherland, USA, for providing me with the platform, opportunities, and environment to achieve my dream of earning a PhD.

Its is a pleasure to express my sincere gratitude to my wife Nima and sons, Alvi and Adib, for sacrificing their time to allow me pursue my dream and enjoy my time while working on the dissertation.

Finally, I want to thank my parents, for their infinite love, encouragement, prayer and for their faith in me.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF ILLUSTRATIONS

Page

CHAPTER 1

INTRODUCTION

This chapter presents the research background, the problem statement and terminology used, explores the purpose and significance of the work, and discusses its limitations.

Thesis Statement

This research attempts to identify and explore factors that influence user success in a digital library environment. Several models of user success are examined and combined considering ever changing information environment factors and their implications to formulate a new model that best explains user success in a digital library environment.

Background

Today's digital libraries have voluminous content, linked to local and various remote resources and other applications through different standards and protocols accessible via single or multiple interfaces. Searching is complemented by browsing that demands user's subject knowledge, technical skills, etc (Marchionini, 2000a). Determining and measuring all user (human) related variables (human factors) in this context is difficult and sometimes confusing (Belkin, 1992).

Several studies have already been conducted to determine human factors such as users' searching behavior, searching satisfaction, information seeking ability, etc. (Belkin, 1992; Fox and Marchionini, Plaisant, & Shneiderman, 2000b), in a digital library

environment. Technical factors such as searching and browsing functionalities (Arms and Shneiderman, 2000), automatic indexing, controlled vocabulary (Wang, 2003), different techniques of information representation such as previews and overviews, information visualization, and hierarchical structure (Shneiderman, 1998; Marchionini, Plaisant, & Shneiderman, 2000b; Plaisten, 1999), have already been investigated as well.

However, very few studies have been conducted specifically to compare and contrast some of the above mentioned factors, to find the relationships between these factors, and to measure how they affect user success if any, in a digital library environment.

Problem Statement

The complex nature of a digital library infrastructure, functionalities and environment raises some important research agendas that are important in the field of library and information science. The rapid growth in Web-accessible infrastructure, several layer of multiple resources and development embedded in a system such as digital libraries facilitates document access and retrieval. But the integration of multiple layers of resources and digital library design are often done without conducting a user study properly; as a result of which users of digital library can easily be lost in the vast information space of different resources and interfaces (Arms, 2003).

Arms (2003, p. 1) further proceeds by saying “change is also one of the themes of digital libraries and change is one of the problems in designing digital library. Traditional libraries are not easy to use effectively, but they change slowly; users

develop expertise over many years. Digital libraries evolve so quickly that every month brings new services, new collections, new interfaces, and new headaches in fast pacing newly created [W]eb environment."

So, it is clear that digital library infrastructure, design and development and the new functionalities, services and activities a digital library might offer is ever changing and dynamic in nature and integration of users' role is important in digital library environment. Several researchers also emphasized this fact and recommended studying digital library users as stakeholders in this new digital library environment. Computers and networks are of fundamental importance, but they are only the technology. The real story of digital libraries is the interplay between people, organizations, and technology (Arms, 2003).

This idea of studying digital library users has been emphasized in other digital library studies as well. According to Jung (1997) "utilizing digital libraries on the [W]eb, study of the digital library user will become an important item on the information research agenda. To date, little attention has been paid to the role of the user in the new environment and little opportunity has been available to assess variables that address user success. Thus, accepted measures for evaluating of digital library use do not exist" (pp. 5-6).

So, there is a need to identify factors that influence user success in digital library environments and accommodate those factors in the redesign and development of effective digital library systems that would at least justify the huge investment on digital libraries. Evaluating a digital library system in terms of user success is not new and previous research has called for ensuring user success in a digital library context.

According to Jung (1997) “development of a valid user success metric will make it possible to evaluate the effectiveness of different digital library systems and will help produce empirical data relating user success to task performance in digital library environments. A better understanding of the variables that affect user success will also help establish a conceptual and analytical framework to focus research on digital library environments” (p. 6). That is why, Borgman (2000) properly stated that “as digital libraries become more sophisticated, more practical, and more embedded in other applications, the challenges of understanding their uses and users become more urgent. These are inherently interdisciplinary problems, and they will require the contribution of researchers from many backgrounds” (p. 50).

Therefore, the purpose of this study is to investigate several recognized user success models from different fields of study and to integrate them in a digital library context and environment. Aligning with this objective, another purpose is to develop and test a new model within the conceptualized research framework namely; comprehensive plus model that best explains that success or effectiveness.

Definitions of Terms

The Digital Library

The term digital library “upon closer examination, has multiple meanings --- around two themes. From a research perspective, digital libraries are content collected and organized on behalf of user communities. From a library-practice perspective, digital libraries are institutions or organizations that provide information services in digital forms” (Borgman, 2000, p. 51). According to Digital Library Federation (1997),

Digital libraries are organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities.

A large body of literature on digital libraries exists spanning several fields including library and information science, computer science and human-computer interaction and the term digital library is synonymous to virtual library, electronic library, and virtual repository but the "main thrust of this literature is the technical creation of powerful and effective digital libraries" (Jung, 1997, P.5). The rapid advancement and huge popularity of Web and Internet technology makes the digital resources accessible and available anywhere and anytime in the world. The Internet is the platform; the Web is the primary application running on the Internet (Jung, 1997).

This research recognized these facts and defines a digital library as an information system that integrates different kinds of digitized local and remote electronic library resources distributed across networks accessible through a single Web interface by many users from many sites at any time in the world.

Functions in a Digital Library

Literature and different studies supported two broad functions performed by the user in a digital library environment: (1) information search and retrieval and (2) interactivity. Both the functions' performance and outcomes are difficult to measure and previous studies operationalized those functions in terms of user satisfaction within the same environment and context. Jung (1997) used these functions in developing and

conceptualizing his comprehensive model of user success in digital library environment. This study used and applied the same functions in developing and testing the new model of user success in digital library environment. More discussion on this topic is included in the literature review section of this dissertation. Terms such as browsing, information discovery, etc., are often cited in the literature as some of the other functions of a digital library.

User Success Indicators

A review of the literature suggested two categories of broad user success indicators in the computing environments namely behavioral and attitudinal indicators. According to Jung (1997), behavioral indicators include usage and performance, and attitudinal indicators include, among others, user satisfaction. Behavioral indicators measure use patterns in order to determine the level of user success in the computing environment; attitudinal measures operate on the premise that users' attitude toward the system define success. He further proceeds by saying, "enough empirical evidence has now accumulated to show the linkage between attitude (i.e. satisfaction) and behavior (performance) … "(Jung, 1997, p. 7) and, citing Gatian (1994), he stated that strong correlation (r = .97) exists between user satisfaction with the retrieved information and the performance of the system. So User Satisfaction is the most widely used and recognized measure of *user success* in the Web environment which is also utilized and supported by DeLone & McLean (1992, 2003).

User Satisfaction

As stated earlier, user satisfaction is the most widely used and recognized measure of user success in the Web environment, a type of digital library. Most of the previous studies considered user satisfaction as an indicator of system effectiveness and/or usefulness. Since the concept of user satisfaction is highly subjective and difficult to measure, previous studies identified user tasks/roles and based the measurement of user satisfaction on the users' understanding and task accomplishments within the functionalities of the studied domain. This study is no exception. The computing environment under which user satisfaction was measured in previous studies was mainframe rather than today's more and more personal computing environment. User tasks/roles also measured in an individual level rather than organizational which were predominant in previous studies. So, the study of user satisfaction, as a dependent variable needs to be reconsidered within the context of the new digital library domain and computing environment.

Contribution of Existing Models

A comprehensive literature search was conducted on the topics of digital library, user success, and user satisfaction from the broader arenas of library and information science and information systems (IS) to adopt and reuse existing user success models in order to specify a comprehensive model within the context of a prototype digital library. After an attempt to measure user success in a Korean digital library environment, Jung (1997) concludes that "because a digital library environment involves two broad functions-1) information search and retrieval and 2) interactivity with and through the medium-this research posits that measures of both of these functions will show positive correlation with user success" (p. X). His review of the relevant literature

for measures of success in terms of the two functions revealed two key models: “1) The end user computing satisfaction model (EUCS), which consists of five dimensions for measuring user success in an end-user computing environment (thus relating to the search and retrieval function of the digital library). 2) The flow model, a four-dimension instrument used to study human-computer interaction” (p. X). So, the EUCS and flow models have already been successfully applied in digital library environments and thus provide a solid research background to the current study.

DeLone & McLean (2003) reformulated information system success model is deeply rooted in Shannon and Weaver’s (1949) early work on Information theory. According to the theory, information could be measured at three levels: technical, semantic, and effectiveness. Citing Shannon and Weaver, DeLone & McLean (1992) define the technical level (systems quality) as “the accuracy and efficiency of the systems that produce the information,” the semantic level (information quality) as the “success of the information in communicating their intended meaning,” and the effectiveness level (use, user satisfaction and net benefits) as the “effect of the information on the receiver” (p. 91). Therefore, in the current study, incorporating DeLone & McLean’s (2003) reformulated information system success model and exploring its constructs is relevant and equally important to measure user success in the prototype digital library environment.

Research Approach

This is both an exploratory and a confirmatory research in terms of combining variables found in Jung’s (1997) and DeLone & McLean’s (2003) models and attempting to develop and test a new model within the conceptualized research framework that

focuses on common factors in these two models related to overall satisfaction in digital library environment. Similar to the previous studies, this research considered digital library functions and users' roles and activities embedded in the digital library environment that can be aligned to user success in terms of studying relevant user success factors and the corresponding theories and models in digital library context and environment.

This is also an exploratory study at least for one reason. This study utilized the variables found in Jung's (1997) comprehensive model of digital library user success which is based on the factors in the EUCS and flow models and their respective measures/items in the instrument in order to explore the appropriateness of the measures/items. EUCS and flow models were discussed more in the literature review section.

Jung's (1997) comprehensive model of digital library user success (comprehensive DLUS), a major and important model of user success tested in a digital library environment, has never been tested and validated by other researchers. It is very important to test such a model in order to build a strong research base on measuring success or effectiveness of digital libraries and to justify huge investments on digital libraries. Furthermore, comprehensive DLUS has been tested in Korea where the research background and culture is different. Jung (1997) duly acknowledged the fact that "external validity may also be affected by the cross-cultural nature of the research" (p. 143).

Results of Jung's (1997) study concluded that empirical testing of flow model didn't show enough significance. He recommends that "future research should utilize a

more comprehensive theoretical framework including both flow variables and possible intervening variables" (p. 147). Possible intervening variables include system quality, service quality, use and user satisfaction that were included in DeLone & McLean's (2003) reformulated information system user success model. Both the original (1992) and reformulated (2003) DeLone & McLean's IS user success model are based on Shannon and Weaver's (1949) classical information theory which was not been tested in a Digital library environment. Some of the reformulated (DeLone & McLean, 2003) IS user success variables might also be appropriate for measuring digital library user success. DeLone & McLean's original (1992) and reformulated (2003) IS user success models were tested in a portal and ecommerce environments similar to the prototype digital library to be used in the current study.

This research is also intended to explore user success in digital library using a real target population consisting of students who currently use a digital library system at a major public university in the United States. The success factors were identified and explored based on participants' responses to an online questionnaire (Appendix B). This online questionnaire is an adaptation of instruments that were used to test and reformulate comprehensive DLUS (Jung, 1997) and DeLone & McLean's (2003) reformulated information system user success models. They were tested and validated in several previous studies successfully within digital library environment similar to the digital library used for the current study.

Therefore, the main goal of this research was to develop a conceptual model of the relationships among user success factors in a digital library environment based on Jung's (1997) and DeLone & McLean's (2003) models of user success as well as test

the combined model to determine possible factors that can best predict user success in a digital library environment.

Research Questions

RQ1. To what extent does the comprehensive digital library user success model (DLUS), based on a combination of the EUCS and flow models, describe overall user success in a prototype digital library environment?

RQ2. To what extent does a combined model of the comprehensive DLUS (1997) and DeLone & McLean's (2003) reformulated information system success model explain digital library user success in a prototype digital library environment?

Significance of the Study

This study was designed to verify findings of a study that tested the comprehensive digital library user success model (DLUS), a major and important user success model in a digital library environment, in a non-English speaking country. It will enrich library and information science literature by providing a combined user success model that tries to integrate recognized models of user success from several studies. Furthermore, the results would serve as a basis for a conceptual framework for the relationships between user success factors in digital library and will lead digital library system designers to concentrate on the relevant success factors while designing digital library systems.

Limitations of the Study

This study uses only a single prototype digital library system which is a combination of both local and remote resources though lacks in information coverage and some functionality like personalization feature. This might be a limitation considering the wide range of different variables and scope of the study. The study also doesn't use Information Quality --- a factor in DeLone & McLean's (2003) model of user success due to the lack of information coverage harvested in this prototype digital library environment. The final sample size of 160 (i.e. out of the total of 191 completed questionnaires) participants, while more than adequate for an exploratory and correlational study such as this, will also be a limitation considering the nature and scope of the study and broad functionalities offered by a digital library system.

Summary

The study of a digital library in today's individual computing and ever changing information environment is challenging and exciting. Adding human aspects and measuring their success is even rewarding in this environment since it is highly subjective and difficult to measure. Several theories on user satisfaction and their corresponding user success from different fields of study gave a unique opportunity to further investigate the challenges of measuring user success in a digital library environment that will be discussed thoroughly in the subsequent chapters.

This chapter presents the general background, problem statement, definition of different terms associated with the study, various theories and models that initiated the research interests of this study, the research questions, and briefly describes approaches utilized to frame those questions. Significance and limitations of this study concluded this section.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

This chapter explores and critically reviews related literature on Digital library as an information system (IS), IS success factors and presents discussions of several relevant theories, models and instruments to test the IS success models.

Digital Library as an Information System

As stated earlier, this research defines a digital library as an information system that integrates different kinds of digitized local and remote electronic library resources distributed across networks accessible through a single Web interface by many users from many sites at any time in the world. Noerr (2003) posits that “the really important point is that a digital library has material stored in a computer system in a form that allows it to be manipulated (for instance, for improved retrieval) and delivered (for instance, as a sound file for playing on a computer) in ways that the conventional version of the material cannot be” (p. 3).

Despite some arguments about the definitions of digital library, in terms of its content, context, and functionalities it might offer, several synonyms such as "electronic library" and "virtual library" are often used. According to Association of Research Libraries (ARL), a leading organization, there are many definitions of a "digital library.” Terms such as "electronic library" and "virtual library" are often used synonymously. The elements that have been identified as common to these definitions are:

1. The digital library is not a single entity

2. The digital library requires technology to link the resources of many
3. The linkages between the many digital libraries and information services are transparent to the end users
4. Universal access to digital libraries and information services is a goal
5. Digital library collections are not limited to document surrogates: they extend to digital artifacts that cannot be represented or distributed in printed formats (ARL, 1995).

Based on the above definitions, it is clear that a digital library is an integrated information system which is a part of an organization that has several components embedded in a way that facilitates gathering, organizing and retrieving information.

Collections in a Digital Library

Collections in a digital library are basically comprised of documents that are in the system and can be characterized in two ways: content and context. Content defines the intellectual content of the document or, in other words, what the document is all about. Context defines the situation or how to describe the document and the processes to define the document. There is an abundance of literature devoted to these topics and they were discussed briefly in the subsequent section.

Contents of collections in a digital library are heterogeneous and diverse in all aspects. Collections in a typical digital library include commercially acquired content as well as locally created/published resources. In this research, the prototype digital library has both local and remote collections and they are virtual in nature with some resources residing locally and some distributed among geographically dispersed repositories.

A repository is a collection of databases that has some logical and physical organization to search and retrieve its content easily. Within this repository, multiple

content formats are often represented through multiple metadata schemes, such as Dublin and Qualified Dublin Core. The studied prototype digital library used Dublin core in matching with remote resources and Qualified Dublin to describe and retrieve local resources. Noerr (2003) stated that both Dublin and Qualified Dublin Core schemes "are concerned with the description of the material, both as to its content and to its physical and descriptive attributes. They are generally very complex (MARC has some 800 field definitions) and cover the most difficult, intellectual, part of the object definition. These definitions are necessary for processing the material and also for searching for it" (p. 94).

Content selection is also not an easy job and among the most challenging issues that need to be addressed in a digital library environment. These include establishing policies and processes for content selection, collection development funding, quality control and management of access rights (Fox, 1998). Generally speaking, the content is a collection of three kinds of documents, namely structured, semi-structured and unstructured (Cheng, 2001). Digital library collections contain mainly semi-structured and structured documents with several identifiable attributes but they might also contain unstructured documents such as those searchable through search engines like Google.

Functionalities Offered by a Digital Library

There are several functionalities offered by a digital library system and the prototype digital library system used in the current study is no exception. In a traditional Online Public Access Catalog, the common means for searching is through Keywords. According to Noerr (2003) "Searching is also pivotal to use of a digital library and it is worth spending some time in consideration of what you need for your library" (p. 36).

Browsing is also common in most digital library systems. According to Arms (2003) “Searching can be supplemented by browsing or can be combined with browsing based on the protocols and standards used, network connections, database environment, retrieval algorithm design, etc. Browsing is the general term for the unstructured exploration of a body of information; it is a popular and effective method for discovering the unexpected” (p. 131). He further proceeds by saying, “The most widely used Web information service, Yahoo!, is fundamentally a classification of Web resources, augmented by searching. Digital libraries with their hyperlinks lend themselves to strategies that combine searching and browsing” (p. 132).

Information search and retrieval is one of the main functionalities offered by a digital library system, including the prototype digital library used in the current study. But the whole process of search and retrieval functions depend on successful implementation of several complex and interrelated information organization techniques such as categorization, automatic indexing, controlled vocabulary, natural language processing, and others.

To evaluate and measure the information retrieval performance of digital libraries, two long-standing criteria are precision and recall (Cooper, 2001) and “Each refers to the results from carrying out a single search on an IS for a given body of information. The result of such a search is a set of hits. Ideally every hit would be relevant to the original query, and every relevant item in the body of information would be found. In practice, it usually happens that some of the hits are irrelevant and that some relevant items are missed by the search” (Arms, 2003, p. 141). Arms (2003) further argues that “Today, searching is usually interactive --- Performance criteria, such

as precision and recall, measure technical properties of aspects of computer systems. They do not measure how a user interacts with a system, or what constitutes an adequate result of a search --- The effectiveness of information discovery depends upon the users' objectives and how well the digital library meets them" (p. 142).

So, it is clear that precision and recall are not the definitive evaluation criteria, at least for a digital library system but the user interaction within the digital library system and their roles and objectives should be counted as well, to explore the digital library system evaluation and related user success. More arguments in favor of this concept will be discussed in the subsequent sections.

Processes and Interactions Involved in a Digital Library

These interactions and processes involved within the digital library environment are often ignored. As indicated in the previous discussion, there are processes involved during the interaction between the user and a digital library system that significantly affect information retrieval from the heterogeneous collections harvested in the digital library system. Several related studies also found interactions between the system and the human processes working at the same time with the "Person in The Loop, or PiTL." (Kantor, 1994). Belkin (1999), Marchionini (1995) and Ruthven (2003) found that users are not static in relation to the system. They formulate and reformulate queries, refine the searches, browse the whole or partial site, jump from one site to other sites, etc.

In an attempt to measure a specific information problem that requires a solution, Stettheimer (2000) identified "four primary forces namely the individual (user), the problem (task), the potential solution (system) and the organization" (p. 3). According to

her, these are the recognized forces and she described “six possible interactions among them as follows:

1. User-system: this interaction has historically been related to the field of Human Computer Interactions (HCI) and can be globally represented by a measure of system satisfaction.
2. User-task: this interaction can be represented by a measure of information requirement.
3. User-organization: an interaction which encompasses not only the user’s particular place within the organization, but also the user’s attitudes; job satisfaction is linked to this interaction.
4. System-task: an interaction that has only recently received formal attention, this can be characterized through a measure of task-technology fit.
5. System-organization: an interaction that involves the degree to which the organization champions, endorses, or requires use of a system, i.e. the organizational support for the system.
6. Task-organization: this interaction describes the value an organization places on a particular activity or information and typically reflects the impact the task has on the organization’s continued existence. (p. 6).

Aligning with these interactions, users’ skills and knowledge to implement a specific task also depend on their cognition, behavior, etc. and previous experiments showed positive results by incorporating behavioral and attitudinal information to measure the effectiveness of a system. This study also incorporates several behavioral and attitudinal factors found in previous literature to form a sound basis in evaluating user success in digital library.

Information Systems Success

Despite the large number of empirical studies on IS success, what exactly is meant by information system success has never been clear nor has there been much agreement among researchers (Garrity and Sanders, 1998). According to Molla & Licker (2001), “It appears that IS success is one of the controversial issues that has

eluded IS researchers. The problem is compounded because *success* is a multidimensional concept that can be assessed at different levels (such as technical, individual, group, organizational) and using a number of not necessarily complementary criteria (such as economic, financial, behavioral and perceptual)" (p. 133).

As an information system, the same is true for measuring user success in a digital library. There are so many interrelated variables at different levels working together that sometimes it is hard to even define success in digital library context. Traditional measures of precision and recall in assessing an information retrieval system like digital library will not be applicable as stated earlier in measuring overall digital library user success. In addition to Arms (2003), Su (1992, p. 13) also concludes that "such traditional success measures as precision and recall were not significantly correlated to overall success." Instead, Su (1992, p. 13) determined that a user's satisfaction with completeness of the search result was the best single indicator of user success in the system. Stettheimer (2000) also stated the same fact in analyzing the above mentioned interactions as "the confluence of all primary forces: user, system, task and organization --- this interaction, while difficult to quantify, can best be conceptualized as an overall user satisfaction measure centered within a specific situational context" (p. 8).

So, it is apparent that, despite controversies in measuring how and what to measure as well as how to define success and in what context and environment, user satisfaction is one of the most important single user success indicators in both library and information science and business literature.

User Satisfaction: Brief Overview

Aligning with the previous studies and findings, this researcher has also utilized user satisfaction as being the most important and effective indicator of user success in a digital library environment. The IS literature is very rich in terms of measuring user success and one of many approaches to define this success as a dependent variable is to operationalize this multidimensional concept using several measures based on user tasks and domain functionalities. Applying this approach in this research will have two definite advantages: opportunities to adopt the tested and validated existing user success theories in the same environment and reuse and adopt the corresponding instruments to measure those successes in the studied prototype digital library.

Baroudi (1987) grouped user satisfaction into three categories and combinations of 22 factors: 1) System related factors (reliability, accuracy, precision, relevancy and completeness of output), 2) Interface related factors (technical competence and attitudes of the information service staff, etc), and 3) user-related factors (user feelings, understandings, participation and assessment, etc). Bailey and Pearson (1983) identified 39 factors in an earlier study. Ives and Olson (1983) adopted 3 broad factors in user satisfaction but all these studies are either in a work group or in organizational settings. Jung (1997) stated that “all these dimensions were measured in mainframe computing environment which is not true in more individualized environments such as the [d]igital [l]ibrary” (p. 11).

So all the early user satisfaction theories focused more on organizational level rather than individualized and the need arose to change the user satisfaction model after the 1980’s personal computer revolution. In an end-user computing environment like digital library, a user has direct interaction with the system and thus avoids the early

age computing influence. In response, several models flourished and most importantly Doll's (1988), Joshi's (1990), and Kettinger's (1994) model of user satisfaction ranked and cited highly in the literature. In early 1990's, DeLone & McLean's (1992) IS success model and in early 2000's DeLone & McLean's (2003) reformulated IS success theory shaped up the user satisfaction construct and it has been continuously used since then as a strong predictor of user success in a domain. According to both the theories (DeLone & McLean, 1992, 2003), the later theory with some minor additions, there are six categories of measures of information systems success, one of which is user satisfaction. The six categories are as follows:

- System quality: measures of the information processing system itself.
- Information quality: measures of the information system output.
- System use and usage: measures of recipient response to the information system.
- User satisfaction: measures of recipient response to the information system.
- Individual impact: measures of the effect of information on the behavior of the recipient.
- Organizational impact: measures of the effect of information on organizational performance.

Based on an extensive literature review, DeLone & McLean concluded that user satisfaction is the most widely used and successful measure of success. Jung (1997) also utilized this concept as, "This thesis relies on attitudinal indicators (that is, user satisfaction) to define user success in the digital library --- the basic question to be addressed is: which measures are most likely to be adaptable to a digital library domain? Based on an analysis of the computing environment of the digital library, it is

concluded that there is no single indicator of success and no single measure that can be adapted to define user success in the digital library" (p. 8).

Figure 1 summarizes the user satisfaction dimensions, the user satisfaction theory evolution, and depict the dimensions of the proposed model by the researcher:

Among these theories and their corresponding models, Joshi's (1990) model (Table 1) balanced organizational and individual level of overall user success in end user computing environments such as digital library environment and Jung (1997) adopted Joshi's instrument to measure the dependent variable --- user success --- and thus proven a valid instrument to measure user success in the digital library environment. This study adopted Joshi's instrument as well to measure overall digital library user success.

Table 1

Joshi's Overall User Satisfaction Measures

Q1. How do you feel about the system in terms of its ability to meet the information needs of your area of interest?
Q2. How do you feel about the system in terms of its ability to meet the requirements of all the users they serve?
Q3. How do you feel about the efficiency of the system?
Q4. How do you feel about the effectiveness of the system?

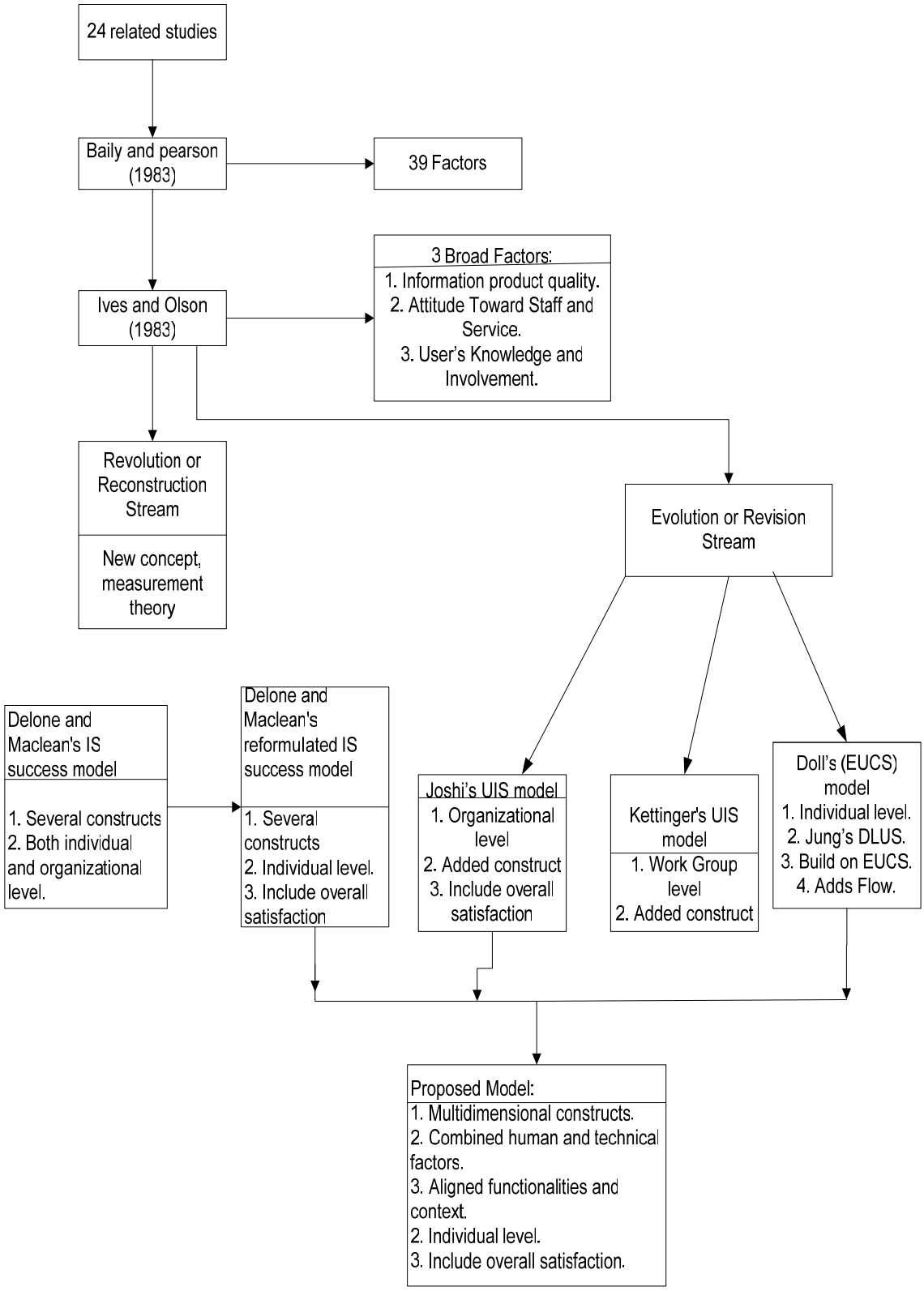


Figure 1. User satisfaction dimensions, evolution and proposed model dimensions (adapted from Jung, 1997, p. 28).

User Satisfaction in Digital Library: An Important User Success Indicator

As mentioned earlier, a review of the literature suggested two categories of broad user success indicators in the computing environments namely behavioral and attitudinal indicators. User satisfaction is an example of attitudinal indicators and a strong indicator in digital library user success that were discussed more in the subsequent section.

There are few or little literature in the fields of library and information science (LIS) that empirically studied user success in digital library environments. Jung (1997) faced the same problem in conducting a similar digital library user success study and stated, “Because there has been virtually no empirical study of the digital library user, this research looks to user success measures developed in related fields” (p. 8). In Business studies, more specifically in management information systems (MIS), there is an abundance of literature that studied specific Information systems (IS) like a Web portal, for example, which is similar to a digital library, measured its success and effectiveness both from the system and human perspective and thus provided a solid research background for the current study.

In IS success literature, highly recommended are two grounded theories of measuring user success, namely the end user computing satisfaction (EUCS) and DeLone & McLean’s IS success model. In a digital library context, and considering two major broad functions namely information search and retrieval and interactivity, in addition to these two models, Jung (1997) adopted another user success model, the flow model, derived from human-computer interaction (HCI) and computer-mediated communication (CMC) fields. In his research, he combined the underlying factors

described in EUCS and flow models and tested those factors in terms of a set of digital library user tasks and validated a new model which he named comprehensive model of digital library user success (henceforth, comprehensive DLUS). This dissertation research proposes a model by combining the comprehensive DLUS and another recent grounded theory of measuring user success --- DeLone & McLean's (2003) reformulated information system success model which is appropriate for describing a digital library environment considering the dimensions included in this model. The research framework section will discuss more on this topic. All the models introduced and described below so far have one commonality; user satisfaction is a dependent variable that can be utilized as a success indicator in studying and measuring user success in a digital library.

Theoretical Framework

In a digital library environment, several human factors (users' searching behavior, searching satisfaction, information seeking ability, etc.) (Belkin, 1992; Fox and Marchionini, Plaisant, & Shneiderman, 2000b), and technical factors (searching and browsing functionalities) (Arms and Shneiderman, 2000), controlled vocabulary (Wang, 2003), different techniques of information representation such as previews and overviews, information visualization, and hierarchical structure (Shneiderman, 1998; Marchioni, 2000; Plaisten, 1999) are involved that can be measured in terms of digital library functionalities and services offered in a digital library context and environment.

A digital library involves two broad functions:1) information search and retrieval and 2) interactivity with and through the medium (Jung, 1997); aligning with the previous

research, I also believe that these two functions broadly constitute all aspects of human and technical factors mentioned above.

The above two functions' performance and outcomes are difficult to measure and can be operationalized in terms of User Satisfaction (Jung,1997) --- a dependent variable, which is widely used to measure information systems' (IS) effectiveness and related user success.

A digital library is an information system (IS) and based on the functionalities and services it can offer, two long-standing criteria, precision and recall, are not the definitive evaluation criteria (Cooper, 2001), at least for a digital library system but the user interaction within the digital library system and their roles and objectives should be counted as well, to explore the digital library system evaluation and related user success.

So, integration of users' role is important in digital library environment and studying digital library user as a stakeholder in this new digital library environment is imperative. Computers and networks are of fundamental importance, but they are only the technology. The real story of digital libraries is the interplay between people, organizations, and technology (Arms, 2003).

The trend of incorporating users' needs in digital library system design and measuring the effectiveness of the system in terms of user success is not new and previous researchers (e.g. Jung, 1997, in creating the comprehensive DLUS model) have emphasized the need for "valid user success metrics in digital library context utilizing two related key models: 1) The End User Computing Satisfaction Model (EUCS), which consists of five dimensions for measuring user success in an end-user

computing environment (thus relating to the search and retrieval function of the digital library). 2) The flow model, a four-dimension instrument used to study human-computer interaction (thus subjective satisfaction in digital library domain)" (p. X).

Comprehensive DLUS doesn't fully explain digital library user success in all cultures and countries since the population used by Jung's (1997) study was a group of users in a non-English speaking country and the intended meaning of the items and thus the results of the study might not reflect the actual situation.

The underlying assumption is that combining human and technical factors in the comprehensive DLUS and DeLone & McLean's (2003) reformulated information system success models might explain more of the variance in the dependent variable --- user success in a digital library --- than either model could have explained separately. DeLone & McLean's (2003) reformulated information system success model, deeply rooted in Shannon and Weaver's (1949) early work on Information theory, might be appropriate for testing in a digital library environment, given its functionalities and services it offers.

Combining DeLone & McLean's (2003) reformulated information system success model and the comprehensive DLUS (Jung, 1997) might better explain user success since the prior model is current, multidimensional and specific to an application (environment) like digital library and the later model has already utilized two success models and practically implied and tested in a digital library environment.

User Success Models

End User Computing Satisfaction (EUCS) Model

In response to the need to measure user success in the end-user computing environment, Doll and Torkzadeh (1988) developed a 12-item end user computing satisfaction (EUCS) model (Table. 3) instrument to be utilized in a traditional main frame data processing environment. The model comprises 5 components: content, accuracy, format, ease of use, and timeliness (Figure 2). Their instrument was regarded as comprehensive because they reviewed a comprehensive list of user success items and conducted a rigorous analysis of previous works focused on user satisfaction though in a different environment and settings. The environment was mainframe computing and the settings were organizational rather than today's personal computing and more individual settings.

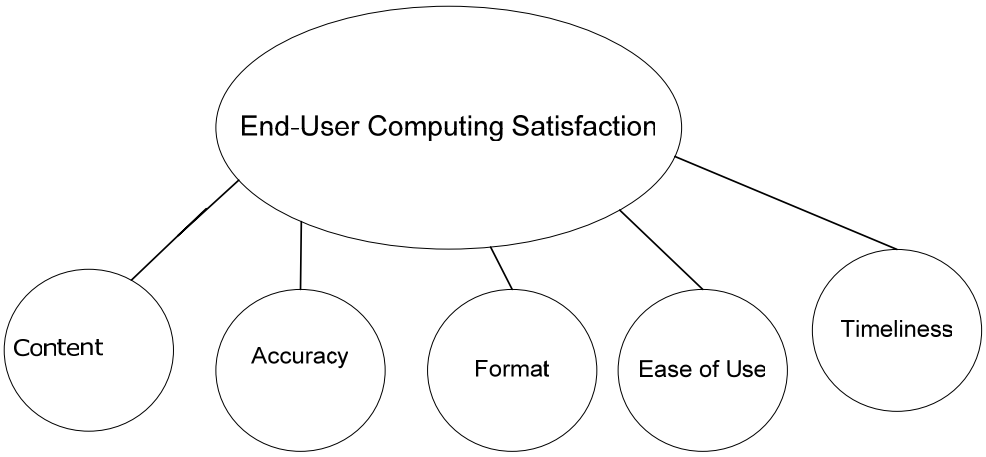


Figure 2. Doll & Torkzadeh's 1998 end user computing satisfaction (EUCS) instrument.

Nonetheless, they included measures of "ease of use," which had not been included in earlier research. Two global measures of perceived overall satisfaction and success were added to serve as a criterion. The 12 items and the 2 global measures

are listed in Table 2. The instrument was developed with a five point Likert-type scale (1 = *almost never*; 2 = *some of the time*; 3 = *about half of the time*; 4 = *most of the time*; and 5 = *almost always*) to measure end user computing satisfaction.

Table 2

Doll & Torkzadeh's 1988 End User Computing Satisfaction (EUCS) Measure

Dimension	Item
Content:	C1. Does the system provide the precise information you need? C2. Does the information content meet your needs? C3. Does the system provide reports that seem to be just about exactly what you need? C4. Does the system provide sufficient information?
Accuracy:	A1. Is the system accurate? A2. Are you satisfied with the accuracy of the system?
Format:	F1. Do you think the output is presented in a useful format? F2. Is the information clear?
Ease of Use:	E1. Is the system user friendly? E2. Is the system easy to use?
Timeliness:	T1. Do you get the information you need in time? T2. Does the system provide up-to-date information?
Global Measures	G1. Is the system successful? G2. Are you satisfied with the system?

Flow Model

As mentioned earlier, the flow model was developed in the human-computer interaction (HCI) and computer-mediated communication (CMC) fields, and is mainly used for understanding and studying the quality of subjective human experience in relation to computing environments (Webster and Trevino, 1992; Ghani, 1995; Hoffman and Novak 1996) such as a digital library. The interactivity functions explained earlier in a digital library context can best be described by flow, as well, because its

instrumentation has several aspects of those interactions that are very difficult to explore and assess. Nonetheless, Jung's (1997) assumption was that dimensions of the flow instrument should correlate with user success in a digital library environment and in line with this assumption he argued that "researchers have suggested that measurement of the user's subjective responses to Web-based computer-mediated communication (CMC) environments (environments in which the computer mediates communication between the user and the hypermedia content of the Web) is necessary to assess overall user success." The high levels of sensory experience and interactivity identified in hypermedia CMC environments suggest that the dimensions of the flow instrument would show a positive correlation to user success in the digital library environment" (p. 17).

A digital library environment is a prime example of CMC since its functionalities and processes involve both technical (machine) and human (user) variables interacting with each other where the user's subjective responses are imperative to measure a digital library user success.

Based on this assumption, Webster et al. (1992) developed an instrument (Table. 3) to test the flow model in HCI and operationalized the variables. Considering the fact that a digital library and a CMC share some common functionalities, such as interaction within the system and are similar in terms of their environments, like end user computing as stated earlier, Jung (1997) operationalized variables in the flow model in a digital library context and concluded that "the dimensions of the flow instrument show a positive correlation to user success in the [d]igital [l]ibrary environment" (p. 17).

Table 3

Webster et al. 1992 Flow Measures

Dimension	Item
Control:	CT1. When using the system, I felt in control. CT2. I felt that I had no control over my interaction with the system. CT3. The system allowed me to control my interaction with the computer.
Focused Attention:	FA1. When using the system, I thought about other things. FA2. When using the system, I was aware of distractions. FA3. When using the system, I was totally absorbed in what I was doing.
Curiosity:	CU1. Using the system excited my curiosity. CU2. Interacting with the system made me curious. CU3. Using the system aroused my imagination.
Intrinsic Interest:	I1. Using the system bored me. I2. Using the system was intrinsically interesting. I3. The system was fun for me to use.

Comprehensive Model of Digital Library User Success (Comprehensive DLUS) Model

Jung's (1997) comprehensive DLUS instrument validated the EUCS (five dimensions, Table.2); flow (four dimensions, Table.3); overall satisfaction (four items, Table 1) and demographic information (7 items) by studying the two constructs (information search and retrieval, interactions) within the context of the digital library user population and "Correlation was found between EUCS and flow, with four dimensions (Content, Intrinsic interest, Control and Timeliness) retained as components of a comprehensive Model of digital library user success" (p. xi).The comprehensive DLUS model was validated with a sample of one hundred sixty-one students (n=161) in Korea and it is one of the conceptual frameworks adopted for this study of measuring user success in a digital library environment.

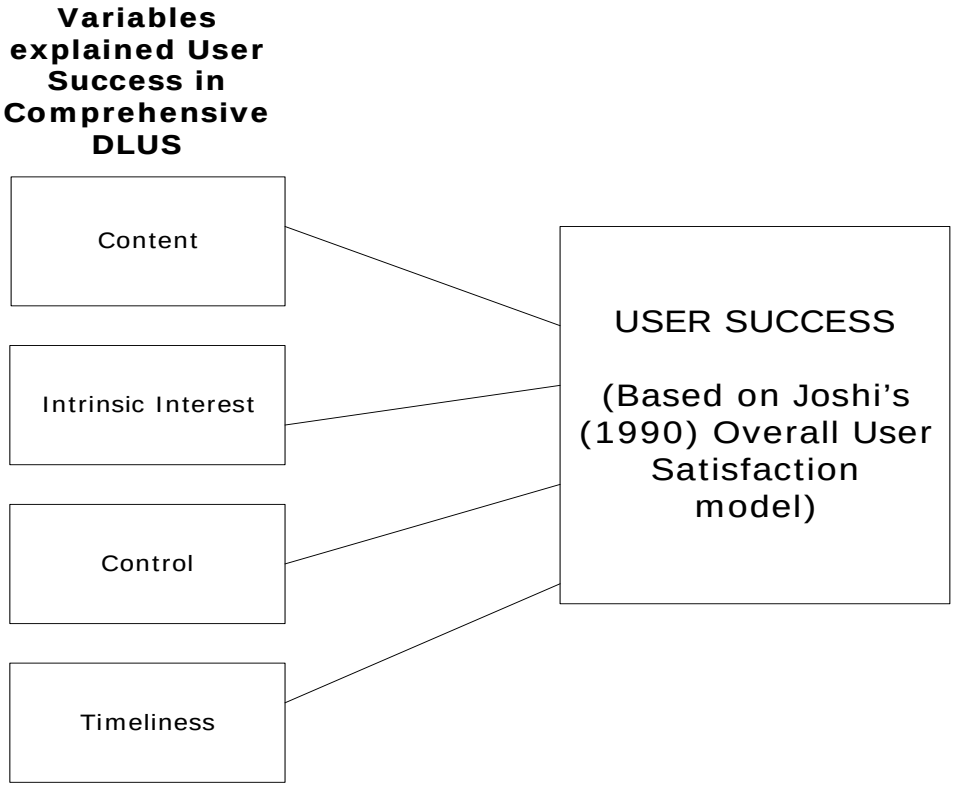


Figure 3. Visual representation of Jung's 1997 IS success model.

DeLone & McLean's Information System Success Model

As stated earlier, the exploration of IS (information system) success or effectiveness has been significantly shaped by DeLone & McLean's (1992) IS success model. Their taxonomy comprises six major categories (see Figure 4) with "temporal and causal' interdependencies."

According to DeLone & McLean (1992, p. 83), "Systems quality and information quality singularly and jointly affect both use and user satisfaction. Additionally, the amount of use can affect the degree of user satisfaction – positively or negatively -- as well as the reverse being true. Use and user satisfaction are direct antecedents of Individual Impact; and lastly this impact on individual performance should eventually have some organizational impact."

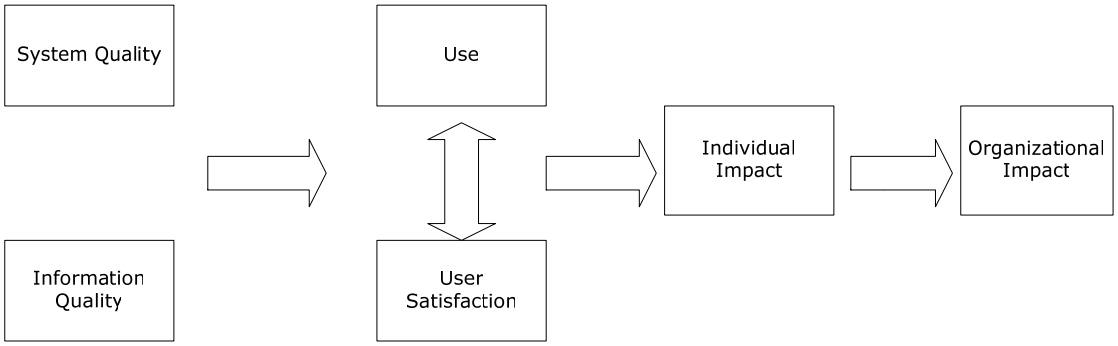


Figure 4. DeLone & McLean's 1992 model of IS success.

DeLone &McLean's model of IS success has been confirmed by a number of subsequent studies. According to DeLone & McLean (2002, p.5), "A citation search in the fall of 1999 yielded 144 refereed journal articles and 15 papers from the International Conference on Information Systems (ICIS) that have referenced DeLone & McLean's model during the period 1993 to mid 1999."

Table 4

*Journal Articles Citing the DeLone & McLean 1992 IS Success Model**

Journals	Number of Articles
Information & Management	24
Journal of Management Information Systems	11
MIS Quarterly	15
European Journal of Information Systems	10
Information Systems Research	7
Decision Sciences	6
International Journal of Management Science	6
Management Science	4
IEEE journals	4
Communications of the ACM	2
IBM Systems Journal	1
Other journals	54
Total	154

Note. Excludes a number of conference proceedings that also cite the model.

However, it also has its own critics as well. Some of the strongest criticisms include mixing variance and process models in one package (Seddon, 1997); misrepresentation of Shannon's model of communication; blurred theoretical underpinning; and the unreality of the unidirectional relationship among use, user satisfaction, individual impact and organizational impact (Garrity and Sanders, 1998) are worth mentioning.

DeLone & McLean's Reformulated IS Success Model

After considering all the criticisms and taking into account the progressive and ever-changing notion of the role of information systems during the last decade, DeLone & McLean (2003) came up with a new model (see Figure 5) namely DeLone & McLean's (2003) reformulated information system success model.

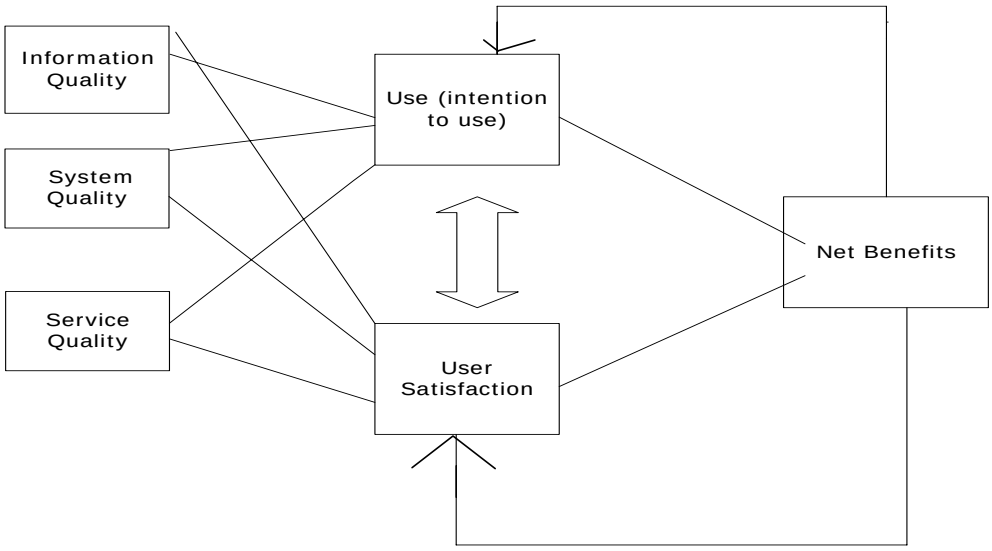


Figure 5. DeLone & McLean's reformulated IS success model.

This new model is conceptually similar to the old model and according to the IS success literature, it is still a valid and very important IS success theory. According to DeLone & McLean (2003, p. 9), “Despite the recent research studies which both support and challenge the original DeLone & McLean’s IS success model, we believe that our original conclusions still form a sound basis for IS success measurement. The changes in the reformulated information system success model are largely changes in degree, not in kind. The addition of Service Quality and the collapsing of Individual Impacts and Organizational Impact into Net Benefits still preserve the parsimonious nature of the model.” Several IS researchers supported that Net Benefits and User success are synonymous and imply the same meaning and for maintaining the consistency of this study, I used User Success instead of Net Benefits.

Table 5

DeLone & McLean's 2003 Reformulated IS Success Model Metrics

Dimension	Item
Systems quality:	S1. Adaptability S2. Availability S3. Reliability S4. Response time S5. Usability
Information quality:	I1. Completeness I2. Ease of understanding I3. Personalization I4. Relevance I5. Security
Service quality:	SQ1. Assurance SQ2. Empathy SQ3. Responsiveness
Use:	U1. Nature of use U2. Navigation patterns U3. Number of site visits U4. Number of transactions executed

(table continues)

Table 5 *(continued).*

Dimension	Item
User satisfaction:	US1. Repeat purchases US2. Repeat visits US3. User surveys
Net benefits:	N1. Cost savings N2. Expanded markets N3. Incremental additional sales N4. Reduced search costs N5. Time savings

Research Framework

Jung's (1997) digital library user success model (comprehensive DLUS) is an important and valid user success model but it was tested in a non-English speaking country. Item meanings, the effect of cross translation on user responses, and different cultural settings might affect the research findings negatively and the model needs to be tested in an English speaking country where the above mentioned problems can be avoided.

Jung's model was tested and validated almost nine (9) years ago and the dynamic and ever-changing nature of information environments like a digital library demand inclusion of current user success dimensions/factors to explain that success.

DeLone & McLean's (2003) reformulated information system success model is a popular and most important user success models that researchers in different fields have been using and testing frequently. According to DeLone & McLean (2003, p.3), "A citation search in the summer of 2002 yielded 285 refereed papers in journals and proceedings that have referenced D&M Model during the period 1993 to mid-2002.

Many of these articles positioned the measurement or the development of their dependent variable(s) within the context of the D&M IS Success framework."

DeLone & McLean's (2003) reformulated information system success model is deeply rooted in Shannon and Weaver's (1949) early work on Information theory. Therefore, incorporating DeLone & McLean's (2003) reformulated information system success model and exploring its constructs is relevant and important to measure user success in the prototype digital library used in the current study.

It is also clear that context is a very important facet when the researcher applies DeLone & McLean's (2003) reformulated information system success model. In this prototype digital library context, information quality construct wasn't included as stated earlier because there is not enough information harvested in the studied prototype digital library system. This idea has also been supported by DeLone & McLean's (1992) original model as "researchers should systematically combine individual measures from the IS success categories to create a comprehensive measurement instrument" (p. 87).

The two most widely used criteria of IS success are use and user satisfaction and they are used, along with other independent variables found in the IS success literature, to measure the prototype digital library user success.

The proposed model is designed to measure user success at the individual level rather than organizational level given the fact that the digital library is an individualized computing environment.

Finally, the proposed model emphasized the digital library context and broad functionalities that a digital library system might offer rather than concentrating on any

task specific activities that might be too narrow in nature when evaluating a digital library user success.

Proposed User Success Model

As previously stated, the purpose of this study is two fold: (a) to investigate and explore several recognized user success models from different fields of study that explain user success in an information environment such as a digital library and (b) to develop and test a new comprehensive model within the above conceptualized research framework namely, comprehensive plus model that best explains user success.

In line with the previously stated theoretical and research framework, the proposed model (Figure 6) can be summarized as follows:

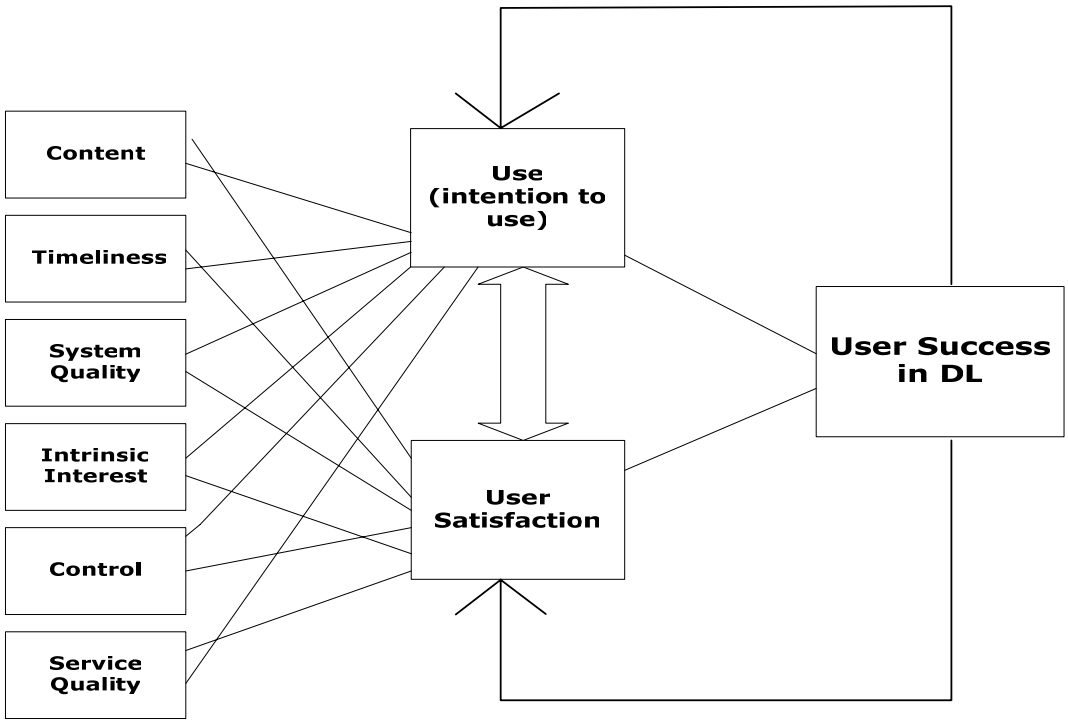


Figure 6. Proposed comprehensive plus user success model in DL.

Table 6

Item Mapping with Corresponding Factors and Representative Models

Factors:	Original model:
Content	End user computing satisfaction (EUCS)
Timeliness	End user computing satisfaction (EUCS)
System Quality	DeLone & McLean s (2003) reformulated information system success model
Intrinsic Interest	Flow model
Control	Flow model
Service Quality	DeLone & McLean's (2003) reformulated information system success model
Use (intension to use)	DeLone & McLean's (2003) reformulated information system success model
User Satisfaction	DeLone & McLean's (2003) reformulated information system success model
User Success in digital library	Joshi's overall user satisfaction model.

Summary

This chapter presents the literature review of the study. The concepts of digital library and its functions, processes and interactions were discussed in detail. The concept of information systems (IS), user satisfaction and success as well as its indicators were discussed as well. Existing theories of user satisfaction and various related models were examined to specify the theoretical and research framework of this study, which is the comprehensive plus model of user success in a digital library environment. The proposed user success model was tested and methods used as well as results of data analyses are presented in the subsequent chapters.

CHAPTER 3

RESEARCH DESIGN AND METHODS

Introduction

This chapter presents the design of the study and the methods used for exploring possible factors, based on models derived from the literature of both the LIS and Business studies that affect the dependent variable --- user success in a digital library environment. Literature (Griffiths, 2002; Borgman, 2000; Williams, 2003; Huang 2003) supports different kinds and combinations of research methods and techniques to measure both the human and technical factors of systems design issues in a digital library environment. Examples include online questionnaires, interviews, ethnographic studies, Delphi studies, and sometimes combinations of two or more based on the types of research questions.

Digital Library Environment

The prototype digital library system is a combination of both local and remote resources accessible through the World Wide Web. The system is only available to the University of Texas at Dallas (UTD) students, staff and faculty. The local resources are proprietary and home grown from the UTD special collection department. The remote resources are several databases provided by the vendors for a fee. The digital library system allows searches in both the resources of the digital library and the local catalog at the same time through federated searching mechanism and combines all the results via different standards and protocols and displays the result on a single page. The user then clicks a desired link (if any) and is directed to the desired resource's page. The

federated searching process allows users to search multiple databases and the catalog through a single unified mechanism instead of going to each interface separately. Several human and technical factors are involved in this process as discussed above and the goal of this study is to identify and measure those factors within the general framework of the comprehensive plus model, a model for user success in a digital library environment which takes all of these factors in to account, as well as test the model.

Participants

A convenient sample of 300 UTD students was asked to serve as study participants. The digital library usage log was used to identify this logical number and after masking their personal information they were solicited to participate in the study. All users in the sample were recruited via invitations that I sent. A copy of the consent form and cover letter is included in Appendix A for reference. Among the 160 users (participants) who provided complete and usable data are students ranging in status from undergraduate to master's level. The prototype UTD digital library system is available at http://encompass.utdallas.edu. Participants can also find the link under "Test the Federated Search" from UTD library Catalog available at http://library.utdallas.edu. Participants were also given the option to familiarize themselves with the functionalities and services provided by the prototype UTD digital library if they thought they are not comfortable enough using the system. The reason for that is to achieve a homogeneous sample of participants who have the same level of experience in using the domain and familiarities using the system and thus satisfy some

of the internal validity (for example, level of experience with an information system) issues raised in the literature. But this research doesn't measure the users' level of experience and this issue is beyond the scope of this research. Rather, based on their recent digital library usage experience, they were asked to participate in an online survey and submit their responses to items in the questionnaire. The digital library usage experience can be a combination of searching and browsing tasks, interaction with different interfaces and domains and other related activities using an information system like the prototype digital library. As stated earlier, rather than specifying any definite tasks and to measure the success based on those tasks, this study accounts for all the tasks found in the literature as a single set of general tasks and activities and, at least theoretically, those tasks culminate in a combination of human and technical factors that can be operationalized through digital library functions and services that are included as a major component in the proposed comprehensive plus model.

Data Collection

Data collection for this study was based on some assumptions related to theoretical implications and respondents' ability to participate in this study. The two main assumptions are:

1. All the participants are current users of the prototype UTD digital library system. They were selected based on the usage log of the prototype digital library.
2. Since users' level of experience was not measured, I assumed that the group of users in the sample are similar in their level of experience using the system and their domain understanding and, hence, homogeneous in nature.

Jung (1997) tested the end user computing satisfaction Model (EUCS) and the flow model to measure user success in a digital library environment. Combining the

most significant factors from these two models, he then tested and validated a model called comprehensive model of digital library user success (comprehensive DLUS model). DeLone & McLean (1992), after a comprehensive review of various measures used in the literature to assess information system (IS) success, proposed a model that incorporates several individual dimensions of success into an overall model of information system (for instance, digital library) success. After 10 years, considering the technological and information environment changes, DeLone & McLean (2003), dropped some variables (factors) and added and merged some new variables to come up with a model similar to the old model that also depicts overall IS success.

This empirical study adopted items and scales used in similar previous studies, apart from integrating some dimensions and minor changes in wording, in order to develop a survey instrument (an online questionnaire, Appendix B) to measure all the variables in the new comprehensive plus model. The survey instrument is an adaptation of a total of 36 questions and it took each participant about 15 to 20 minutes to complete it. Participants were asked to respond to all 36 questions measuring factors in DeLone & McLean's (2003) reformulated information system Success (15 items), comprehensive DLUS (12 items) (Jung, 1997) and Joshi's (1990) Overall user satisfaction (4 items) models. The remaining 5 items in the instrument relate to demographic information and general comments are sought through open-ended questions. A breakdown of all the above dimensions (factors), corresponding items, original/formulated questionnaire and their detailed mapping in the instrument used in this study are presented in Table 7.

Table 7

Instrument Construction and Item Mappings in Detail

Factors and Sources			Original/Formulated Question	Items in Study Instrument
Comprehensive DLUS: Three Factors:	1) EUCS (6 items total):	Content (4 items)	1. The digital library provided the exact information necessary. 2. The information itself satisfied my needs. 3. The search result was almost exactly the thing I needed. 4. The digital library provided plenty of information.	Q: 1-4. Used as is, no change.
		Timeliness (2 items)	5. The information was produced in a timely manner. 6. The digital library provided up-to-date information.	Q: 5-6. Used as is, no change.
	2) Flow (6 items total):	Intrinsic Interest (3 items)	12. Using the digital library bored me. 13. The digital library is inherently interesting. 14. It was very enjoyable to use the digital library.	Q: 12-14. Used as is, no change.
		Control (3 items)	15. I was confident in using the digital library. 16. I could not control the activities involved in accessing the digital library. 17. When using the digital library, I was able to control all aspects of my access to the computer.	Q: 15-17. Used as is, no change.
	3) Overall User Satisfaction (4 items):		28. I feel the digital library is able to meet my information needs in my area of interest. 29. I feel the digital library is able to meet the requirements of all users it serves. 30. I feel the digital library is efficient. 31. I feel the digital library is effective.	Q: 28-31. Used as is, no change.
DeLone & McLean's (2003) model: Six Factors:	1) Systems quality (5 items):	Adaptability	The digital library was easily adaptable to me.	Q.7. Used as is, no change.
		Availability	The digital library was always available to me.	Q.8. Used as is, no change.
		Reliability	The digital library was reliable to me.	Q.9. Used as is, no change.
		Response time	I was satisfied with the digital library response time.	Q.10. Used as is, no change.
		Usability	The digital library was useable to me.	Q.11. Used as is, no change.

(table continues)

Table 7 *(continued).*

Factors and Sources			Original/Formulated Question	Items in Study Instrument
DeLone & McLean's (2003) model: Six Factors: *(cont.)*	2) Information quality (5 items):	Completeness Ease of understanding Personalization Relevance Security	Didn't use this factor. Mentioned it in the limitations sections. Also justified in the section 2 under literature review.	None.
	3) Service quality (3 items):	Assurance	I was satisfied with the easy way to use the digital library.	Q.18. Used as is, no change.
		Empathy	I have empathy (not enjoyable and comfortable) to use the digital library.	Q.19. Used as is, no change.
		Responsiveness	I was satisfied of the responsiveness of digital library support.	Q.20. Used as is, no change.
	4) Use (intension to use) (4 items):	Nature of use	I use digital library for my class work.	Q.21. Used as is, no change.
		Navigation patterns	I navigate the digital library to find information.	Q.22. Used as is, no change.
		Number of site visits	I visit different sites to find information within digital library.	Q.23. Used as is, no change.
		Number of transactions executed	I download information from digital library in every visit.	Q.24. Used as is, no change.
	5) User satisfaction (3 items):	Repeat purchases	I intend to use the digital library services in the future.	Q.25. Used as is, no change.
		Repeat visits	I intend to visit the digital library in the future.	Q.26. Used as is, no change.
		User surveys	I intend to participate in the digital library User surveys in the future.	Q.27. Used as is, no change.
	6) Net benefits (5 items):	Cost savings Expanded markets Incremental additional sales Reduced search costs Time savings	Didn't use this factor. The studied digital library lacks of some features and some of them already covered by another factors and not applicable in this study. Also justified in the section 2: literature review.	None

Each item in the questionnaire was rated on a 5-point Likert scale where 1 corresponds to *never* and 5 corresponds to *always*. The chosen measures had demonstrated an appropriate level of reliability in previous research. Participants' responses to items in the questionnaire (i.e. the data) were then used to test the proposed comprehensive plus user success model in digital library (Figure 6). Various computer devices such as a dedicated server space and a MySQL database were used to store and maintain users' responses. Several computer programming and markup languages such as PHP and HTML were used to build the online questionnaire page and another computer application was used to extract the data from the database as needed.

Pilot Study

It is true that Jung's (1997) comprehensive DLUS model instrument has already been tested for reliability and validity but it was in a country with a different language and culture. According to Jung (1997), translation and cross translation may also affect the internal validity of the instrument. So there is a need to confirm the instrument's internal validity by conducting a pilot study in the present context and culture. The instrument used to test DeLone & McLean's (2003) reformulated information system Success model has already been tested for reliability in a similar environment (ecommerce) as well but it was not tested when its items are combined with items from another instrument and the combination needs to be tested for reliability (internal consistency).

So, a pilot study has been justified and conducted with a sample of 44 students for two main reasons: to ensure that measures were reliable in the target population and, to improve the research process by testing the instrument on a similar but smaller group of participants. The most common measure of reliability (internal consistency) is Cronbach's (1951) coefficient alpha (α). A widely accepted rule of thumb is that alpha should be at least 0.70 for a scale to demonstrate internal consistency (Spector, 1992).

It is clear from Table 8 that for a sample of 44 participants, most of the Cronbach's alpha values are slightly below or well above the accepted minimum level of 0.70.

Table 8

*Reliability of Items in the Questionnaire: Pilot Study (*n = *44)*

Item #	Factors	Model	Cronbach's Alpha
1-4	Content	End user computing satisfaction (EUCS)	0.86
5-6	Timeliness	End user computing satisfaction (EUCS)	0.65
7-11	System Quality	DeLone & McLean's (2003) reformulated information system success model	0.83
12-14	Intrinsic Interest	Flow model	0.41
15-17	Control	Flow model	0.34
18-20	Service Quality	DeLone & McLean's (2003) reformulated information system success model.	0.46
21-24	Use (intension to use)	DeLone & McLean's (2003) reformulated information system success model.	0.81
25-27	User Satisfaction	DeLone & McLean's (2003) reformulated information system success model.	0.78
28-31	User success in digital library	Joshi's (1990) overall user satisfaction model.	0.86

Data Analysis

The pilot study showed acceptable levels of reliability (internal consistency) of items in the study instrument in measuring the constructs (factors) in the proposed model. However, some of the Cronbach's alpha values are slightly below the accepted level. They deserve, and were given, more attention during the actual survey. I rearranged the items in the questionnaire and presented them in a different order in the instrument during the actual survey in order to improve their reliability (internal consistency).

Any data analysis exercise begins with an examination of the data for each item (measure) and construct (factor) in terms of missing values, outliers, normality (that the set of values of the variable in the population has a normal distribution), reliability, and validity. Reliability of an instrument, more specifically its items that make up a scale, is concerned with interrelatedness of sets of items. It is usually assessed by the degree of inter-item correlation between items that make up a scale or measuring a construct (factor) (Netemeyer, Bearden, & Sharma, 2003; Nunnally & Bernstein, 1994). As stated above, an often used measure/coefficient of reliability is Cronbach's (1951) coefficient alpha (α) which was also used to assess the reliability (internal consistency) of items in the study instrument.

According to Nunnally and Bernstein (1994), validity refers to an instrument's scientific utility and an instrument is valid to the extent that "it measures what it purports to measure" (p. 83). The study instrument was assessed with respect to the three common but closely tied types of validity, namely construct, convergent, and discriminant validity. Construct validity is an indicator of how well an item (measure) in

the instrument actually measures the construct (factor) it is designed to measure (Netemeyer, Bearden, & Sharma, 2003). The construct validity of an instrument is evaluated by looking at intercorrelations among measures of the same construct (factor). If measures (items) that relate to a construct (factor) are at least moderately correlated then they are considered to have construct validity.

Convergent and discriminant validity are subtypes of construct validity. While items in an instrument have convergent validity if they measure the same construct and they are highly correlated, they are said to have discriminant validity if they measure closely related but conceptually different constructs and groups of items measuring a particular such construct have a low to moderate correlation with groups of items measuring the conceptually different construct (Netemeyer, Bearden, & Sharma, 2003). Mainly, factor and correlation analysis were used to determine the (construct, convergent, and discriminant) validity of the study instrument which will be discussed later thoroughly.

Exploratory and Confirmatory Factor Analysis

Simply stated, factor analysis is a set of statistical techniques used to identify groups of related variables called factors. Usually there is a high correlation among variables within a group and low correlation between variables in different groups in order to satisfy convergent and discriminant validity requirements of items used to measure these variables (Nunnally & Bernstein, 1994). This makes factor analysis an appropriate tool for not only identifying which items in an instrument measure which constructs/factors (exploratory factor analysis, EFA) but also for assessing the (construct, convergent, and discriminant) validity of the items (measures). It is an ideal

tool for testing hypothesized measurement models (confirmatory factor analysis, CFA) that depict (define), a priori, the relationships items (measures) and factors have as well (Netemeyer, Bearden, & Sharma, 2003; Nunnally & Bernstein, 1994).

Factor analysis is conducted when a construct (factor) is latent, can not be measured directly, and requires more than one measure, that is, when a construct (factor) is a combination of two or more observable variables (measures). In other words, “the need for factor analysis arises because no single physical measure suffices” (Nunnally & Bernstein, 1994, p. 449). There are three different interpretations of factors as combinations of observable variables (measures). In this study, I followed the “effect indicators” interpretation where the observed variables (measures) are the effects (results, outcomes) of the factor (Nunnally & Bernstein, 1994). For instance, the dependent latent construct in the proposed comprehensive plus model of user success in digital library (see Figures 6 & 7), has four measures (Items 28 to 31 in Appendix B) that are possible effects (results, outcomes) of user success. All the constructs (factors) together with their corresponding measures (items) for the comprehensive plus model are depicted in Figure 7.

Any measurement introduces some error which is assumed to be random rather than systematic and which could be estimated through the process of factor analysis. Error terms for each measure (item) in the study instrument are labeled as δ_i (i=1, 2, 3, …, 20) for measures of independent latent constructs (Content, Timeliness, System Quality, Intrinsic Interest, Control, and Service Quality), and they are labeled as ε_j (j=1, 2, 3, …, 11) for measures of the dependent latent constructs (Use – intention to use, User Satisfaction and User Success) (see Figure 7).

Exploratory factor analysis (EFA) can be used to identify the underlying structure (including common factors) and relationships among a set of observable variables (measure) (Netemeyer, Bearden, & Sharma, 2003). The common factor analysis approach to exploratory factor analysis was used in this study where the main goal is to identify the latent constructs in the comprehensive plus model based on the correlations among the measures (items in the study instrument). Confirmatory factor analysis is useful when the relationships between variables are defined in a measurement model and this definition is based on strong theory and previous research (Nunnally & Bernstein, 1994). It is used mainly to test a specified theoretical factor structure to determine the degree of the factor structure "fit" with "observed covariances among the items in the factor(s)" (Netemeyer, Bearden, & Sharma, 2003, p. 148).

Both exploratory and confirmatory factor analysis were conducted using the LISREL (version 8.80) software (Jöreskog & Sörbom, 1993) and SPSS© version 13.0 for Windows by specifying the relationships between measures and constructs as indicated in Figure 7. Exploratory factor analysis were conducted first (where loadings of all items on all constructs/factors are evaluated) in order to identify appropriate measures for the constructs and decide on which items should be retained and which ones should be dropped. Results of the exploratory factor analysis were used to specify and test measurement models for the constructs through confirmatory factor analysis.

Structural Equation Modeling (SEM)

Structural equation modeling (SEM) is a family of statistical techniques that include path analysis, factor analysis, regression analysis, and structure (covariance

structure) analysis (Schumacker & Lomax, 2004). Path analysis is mainly used to estimate the direct/indirect effects of independent variables on dependent variables while factor analysis as discussed in detail in the previous section is used to test how well a set of observed variables measure latent constructs and test measurement models. Regression analysis is used when the study involves prediction of values of a dependent variable based on known values of one or more independent variables. Structure (covariance structure) analysis, which was used to test the specified models and answer the two research questions in this dissertation, is mainly used to study relationships between latent constructs. Even though SEM is a combination of second generation (first generation is correlational techniques and traditional as well), it is attractive to researchers because it provides a single comprehensive means for data analysis, including testing complex theoretical models' fit to sample data. Both research questions in this study involve assessment of fit of two user success models to sample data and thus the choice of SEM as a data analysis technique was obvious.

Often a structural equation model is composed of measurement and structural models (Schumacker & Lomax, 2004). While the measurement model(s) specifies the relationships between the measures (observable variables) and the latent constructs, the structural model(s) specifies the nature of the relationships (usually linear) between the latent constructs. Some of the conventional notations and symbols used in structural equation models for the various types of variables such as path coefficients, error terms, etc. are given in Table 9 (Jöreskog & Sörbom, 1993).

Table 9

Symbols, Names of Variables and Coefficients Used in SEM

Symbol	Name	Variable, Path or Coefficient
ξ	Ksi	Exogenous (independent) latent variable
η	Eta	Endogenous (dependent) latent variable
γ	Gamma	Path coefficients for a path connecting an exogenous latent variable (ξ) to an endogenous latent variable (η)
β	Beta	Path coefficients for a path connecting an endogenous latent variable (η_1) to another endogenous latent variable (η_2)
Y	Y-variable	Observed variables which depend on the endogenous (dependent) latent variables (η)
X	X-variable	Observed variables which depend on the exogenous (independent) latent variables (ξ)
$\lambda^{(y)}$	Lambda-Y	Path from an endogenous (dependent) latent variable (η) to a Y-variable
$\lambda^{(x)}$	Lambda-X	Path from an exogenous (independent) latent variable (ξ) to an X-variable
ζ	Zeta	Error terms in the structural equations
ε	Epsilon	Measurement errors in the observed Y-variables
δ	Delta	Measurement errors in the observed X-variables

Table 10

Variables, Coefficients and Parameters in the Comprehensive Plus Model

Symbol	Variable, Path or Coefficient
ξ_1	Content – exogenous latent variable(1)
ξ_2	Timeliness – exogenous latent variable (2)
ξ_3	System quality – exogenous latent variable (3)
ξ_4	Instrinsic Interest – exogenous latent variable(4)
ξ_5	Control – exogenous latent variable (5)

(table continues)

Table 10 *(continued).*

Symbol	Variable, Path or Coefficient
ξ_6	Service Quality – exogenous latent variable (6)
η_1	Use (Intention to use) - endogenous latent variable (1)
η_2	User Satisfaction - endogenous latent variable (2)
η_3	User Success (Net benefits) - endogenous latent variable (3)
γ_{11}, γ_{12}	Path coefficients for the path from ξ_1 to η_1 & η_2
γ_{21}, γ_{22}	Path coefficients for the path from ξ_2 to η_1 & η_2
γ_{31}, γ_{32}	Path coefficients for the path from ξ_3 to η_1 & η_2
γ_{41}, γ_{42}	Path coefficients for the path from ξ_4 to η_1 & η_2
γ_{51}, γ_{52}	Path coefficients for the path from ξ_5 to η_1 & η_2
γ_{61}, γ_{62}	Path coefficients for the path from ξ_6 to η_1 & η_2
β_{13}, β_{23}	Path coefficients for the path from η_1 to η_3 & η_2 to η_3, respectively
IU1 – IU4	Observed Y-variables (of η_1) – Use
SA1 – SA3	Observed Y-variables (of η_2) – User Satisfaction
SU1 – SU4	Observed Y-variables (of η_3) – User Success
CT1 – CT4	Observed X-variables (of ξ_1) – measures of the construct Content
TI1 – TI2	Observed X-variables (of ξ_2) – measures of the construct Timeliness
YQ1 – YQ5	Observed X-variables (of ξ_3) – measures of the construct System Quality
IT1 – IT3	Observed X-variables (of ξ_4) – measures of the construct Intrinsic Interest
CL1 – CL3	Observed X-variables (of ξ_5) – measures of the construct Control
SQ1 – SQ3	Observed X-variables (of ξ_6) – measures of the construct Service Quality
λ_{y11} – λ_{y41}	Path from η_1 to the 4 observed Y-variables, respectively
λ_{y12} – λ_{y32}	Path from η_2 to the 3 observed Y-variables, respectively
λ_{y13} – λ_{y43}	Path from η_3 to the 4 observed Y-variables, respectively
λ_{ct1} - λ_{ct4}	Path from ξ_1 to its 4 observed X-variables, respectively
λ_{ti1} - λ_{ti2}	Path from ξ_2 to its 2 observed X-variables, respectively

(table continues)

Table 10 *(continued).*

Symbol	Variable, Path or Coefficient
λ_{yq1} - λ_{yq5}	Path from ξ_3 to its 5 observed X-variables, respectively
λ_{it1} - λ_{it3}	Path from ξ_4 to its 3 observed X-variables, respectively
λ_{cl1} - λ_{cl3}	Path from ξ_5 to its 3 observed X-variables, respectively
λ_{sq1} - λ_{sq3}	Path from ξ_6 to its 3 observed X-variables, respectively
ζ	Error term in the structural equation
ε_{11} - ε_{41}	Measurement errors in the 4 observed Y-variables of η_1, respectively
ε_{12} – ε_{32}	Measurement errors in the 3 observed Y-variables of η_2, respectively
ε_{13} - ε_{43}	Measurement errors in the 4 observed Y-variables of η_3, respectively
δ_{ct1} - δ_{ct4}	Measurement errors in the 4 observed X-variables of ξ_1, respectively
δ_{ti1} - δ_{ti2}	Measurement errors in the 2 observed X-variables of ξ_2, respectively
δ_{yq1} - δ_{yq5}	Measurement errors in the 5 observed X-variables of ξ_3, respectively
δ_{it1} - δ_{it3}	Measurement errors in the 3 observed X-variables of ξ_4, respectively
δ_{cl1} - δ_{cl3}	Measurement errors in the 3 observed X-variables of ξ_5, respectively
δ_{sq1} - δ_{sq3}	Measurement errors in the 3 observed X-variables of ξ_6, respectively

Figure 7 is a structural equation model which is a graphical depiction of the proposed comprehensive plus model, one of the models to be tested in this study. Table 10 presents the observable variables (measures), constructs (latent), coefficients, and parameters in Figure 7.

Use of more than one item to measure the constructs (both independent and dependent) ensured construct validity and minimized measurement error. There are a minimum of two and a maximum of five items in the study instrument (Appendix B) that make up a scale to measure each of the nine constructs in the comprehensive plus model. Please see Table 7 for details.

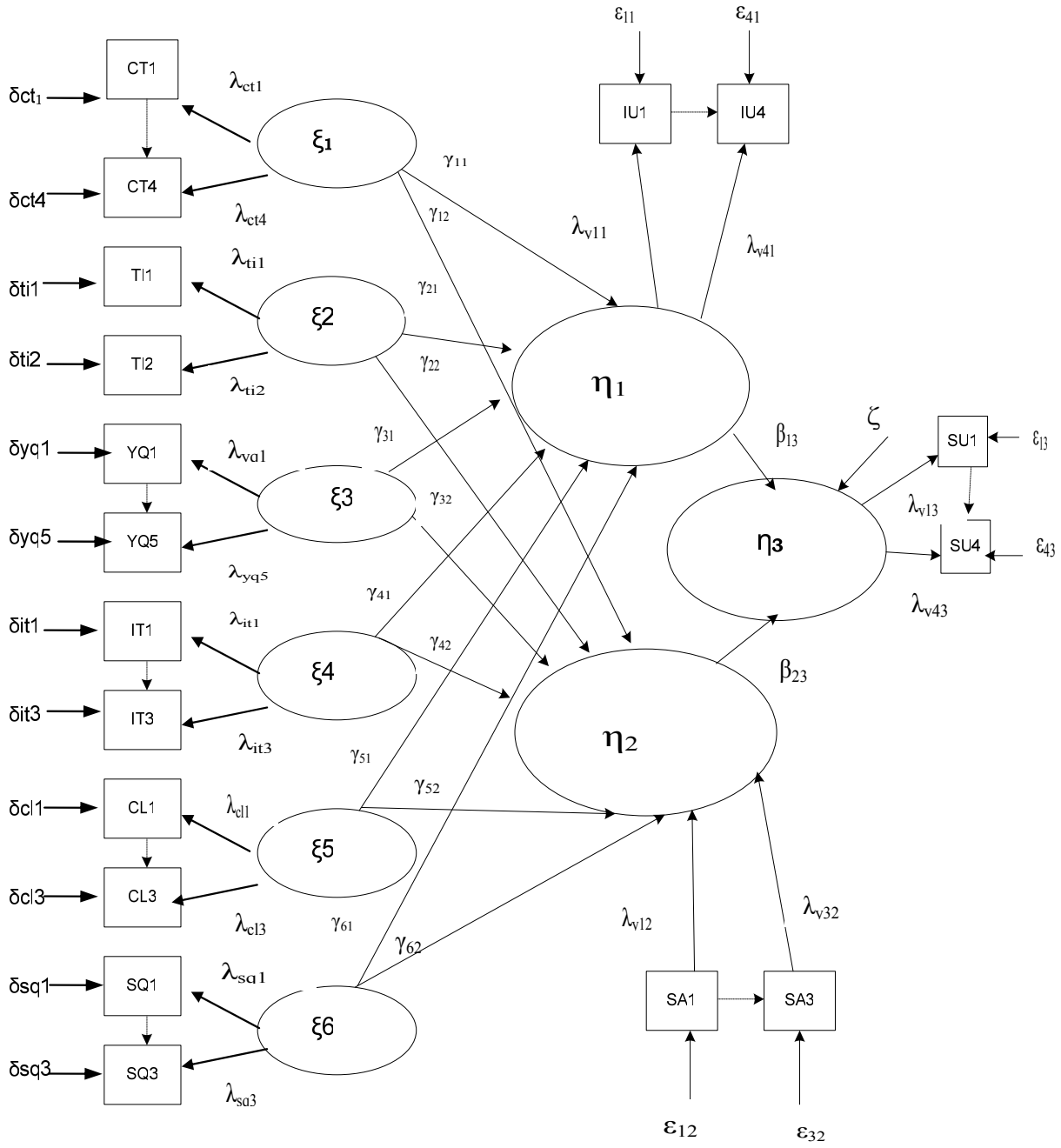


Figure 7. Structural equation model for the comprehensive plus model.

Summary

Chapter 3 describes the digital library environment used for the study, the sample of participants of the study, data collection instrument (an online questionnaire)

and how it was developed based on similar instruments used by previous researchers of information system user success. It also presents the procedures used to solicit responses to the instrument by participants and results of a pilot study conducted to ensure the validity and reliability of the instrument. A detailed discussion of the data analysis methods used, including exploratory and confirmatory factor analyses as well as structural equation modeling, is also presented. The chapter concludes with a presentation of the proposed comprehensive plus model of user success in a digital library environment.

CHAPTER 4

ANALYSIS OF DATA, RESEARCH FINDINGS, AND DISCUSSION

Introduction

As described in the previous chapters, the main goal of this dissertation was to not only develop a conceptual model of user success in a digital library environment based on two previous models, namely Jung's (1997) and DeLone & McLean's (2003) models of user success, but also to test the proposed combined model (the "comprehensive plus" model) and to determine possible factors that can best predict user success in a digital library environment.

To achieve that goal, data were collected from UT Dallas students over a period of eleven (11) months in 2005/6 using a survey instrument (Appendix B) with items that are measures of the latent constructs in the proposed model. They were the primary users of the prototype digital library. Factor analysis and structural equation modeling data analysis techniques namely LISREL & SPSS were utilized to analyze the data. This chapter is a detailed description of the data analyses, major results and findings, as well as a discussion of the results and findings. It depicts participants of the study, presents results of the factor analyses and structural equation modeling and summarizes these results.

Participants

During the academic year (2005/6), the survey was conducted with a total population of around 14,000 students. However, only around 6000 of them were active users of the libraries and around 1700 visited and used the prototype digital library as

revealed by the digital library usage log. Email addresses of 300 repeat users of the prototype digital library were identified and used to solicit participation in the survey. An initial email message was first sent to 200 of them in August 2005 and 79 completed the survey questionnaire within three weeks. I had to send a follow-up email to those users who did not respond to the initial invitation/solicitation three weeks after the initial email was sent. They were asked to complete the questionnaire within two weeks. The follow-up email yielded 53 more completed questionnaire for a grand total response of 132 (66%). A second phase of data collection commenced with another email in March 2006 to 100 more users. The initial email and two additional reminders took a little more than two months to produce 29 more usable responses. The total number of completed questionnaires was 191 for a response rate of 63.7%.

Thirty-one of the completed questionnaires were omitted from analysis due to being incomplete (including those that had one missing/incomplete value/item). The final number of completed and usable questionnaires was 160, a number that is adequate given the nature of the study (exploratory & correlational). Out of the total of 160 participants of the study, there were slightly more female (54.4%) than male (45.6%) participants. This is an acceptable combination and one that is not far from the combination in the University's general student population even though it is not a true reflection of the overall student body at University of Dallas (45% female & 55% male). A significant number of them were undergraduates (63.75%) which explain the fact that the highest level of education for more than half of the participants (52.5%) possess high school diploma. The percentage of undergraduates who completed the questionnaire is around the same as the percentage of undergraduates in the total

student population at UT Dallas (64%) for the data collection period. Table 11 shows the distribution of the participants in terms of their gender, highest level of education or degree completed, and type of user.

Table 11

Distribution of Participants by Gender, Level of Education and Type

		Count	%
Gender	Male	73	45.60
	Female	87	54.40
Highest degree completed	High School Diploma	84	52.50
	Associate	18	11.25
	Bachelors	38	23.75
	Masters	20	12.50
	PhD	0	0
	Other	0	0
Type of user	Undergraduate	102	63.75
	Graduate/Masters	39	24.38
	Doctoral	18	11.25
	Other	1	0.62

Analysis, Research Findings, and Discussion

Data Screening

Survey data were examined in order to see if there are any missing values and outliers as well as to see whether they satisfy the normality criterion (that the set of values has a normal distribution). Because incomplete responses were discarded before the data screening exercise, there were no missing values in the data. A stem-and-leaf display and a box-and-whisker plot were both used to ascertain the presence

or absence of outliers. None of the items/variables had values outside the range of values (1-5) for responses. Table 12 shows the descriptive statistics for all items in the study instrument.

The normality criterion was assessed with the help of descriptive statistics for the items (Table 12), more specifically their skewness and kurtosis values. In order for values of an item/variable to satisfy this criterion both their skewness and kurtosis values must not be significantly different from zero (Tabachnick & Fidell, 1989). As can be seen from Table 12, almost all items had both skewness ($p \geq 0.219$) and kurtosis ($p \geq 0.095$) values not significantly different from zero. The only exception is for Item IT1 in the Intrinsic Interest scale ($p < 0.05$), so their initial values were assumed to be normal scores and were used with that assumption in subsequent analyses.

Validity and Reliability Analysis

Reliability of an instrument, more specifically its items that make up a scale, is concerned with interrelatedness of sets of items. It is usually assessed by the degree of inter-item correlation between items that make up a scale or measuring a construct (factor) (Netemeyer, Bearden, & Sharma, 2003; Nunnally & Bernstein, 1994). An often used measure/coefficient of reliability namely Cronbach's (1951) coefficient alpha (α) was used to assess the reliability (internal consistency) of items in the study instrument.

Table 12

*Descriptive Statistics for Items and Scales in Study Instrument (*n = *160)*

Variable	Scale/Construct & items		Mean	SD	Skew.	Kurt.
CT1	Content	1. The digital library provided the exact information necessary.	3.744	0.906	-0.206	-0.191
CT2		2. The information itself satisfied my needs.	3.744	0.826	-0.233	0.395
CT3		3. The search result was almost exactly the thing I needed.	3.369	0.806	-0.087	0.093
CT4		4. The digital library provided plenty of information.	3.594	0.920	-0.155	-0.178
TI1	Timeliness	5. The information was produced in a timely manner.	3.544	1.063	-0.171	-0.477
TI2		6. The digital library provided up-to-date information.	3.631	1.026	-0.202	-0.514
YQ1	System Quality	7. The digital library was easily adaptable to me.	3.612	0.876	-0.149	-0.135
YQ2		8. The digital library was always available to me.	3.494	0.897	-0.134	-0.108
YQ3		9. The digital library was reliable to me.	3.694	0.824	-0.134	-0.162
YQ4		10. I was satisfied with the digital library response time.	3.769	0.848	-0.130	-0.304
YQ5		11. The digital library was useable to me.	3.681	0.842	-0.085	-0.460
IT1	Intrinsic Interest	12. Using the digital library bored me.	3.575	0.589	0.442	-0.712
IT2		13. The digital library is inherently interesting.	3.031	0.900	0.015	-0.113
IT3		14. It was very enjoyable to use the digital library.	3.056	0.863	-0.030	-0.078
CL1	Control	15. I was confident in using the digital library.	3.244	0.799	-0.031	0.036
CL2		16. I could not control the activities involved in accessing the digital library.	2.987	0.904	0.059	-0.167
CL3		17. When using the digital library, I was able to control all aspects of my access to the computer.	3.369	0.758	-0.037	0.159
SQ1	Service Quality	18. I was satisfied with the easy way to use the digital library.	3.619	0.823	-0.096	-0.152
SQ2		19. I have empathy (not enjoyable and comfortable) to use the digital library.	3.000	0.777	0.050	0.039
SQ3		20. I was satisfied of the responsiveness of digital library support.	3.437	0.822	-0.042	-0.097
IU1	Use (intension to use)	21. I use digital library for my class work.	3.244	0.860	-0.053	0.032
IU2		22. I navigate the digital library to find information.	3.594	0.763	-0.175	0.242
IU3		23. I visit different sites to find information within digital library.	3.750	0.861	-0.175	-0.226
IU4		24. I download information from digital library in every visit.	3.550	0.903	-0.133	-0.038
SA1	User Satisfaction	25. I intend to use the digital library services in the future.	3.713	0.948	-0.122	-0.768
SA2		26. I intend to visit the digital library in the future.	3.800	0.923	-0.170	-0.710
SA3		27. I intend to participate in the digital library User surveys in the future.	3.463	0.699	-0.098	-0.065
SU1	User Success	28. I feel the digital library is able to meet my information needs in my area of interest.	3.575	0.836	-0.148	0.002
SU2		29. I feel the digital library is able to meet the requirements of all users it serves.	3.406	0.920	-0.122	-0.136
SU3		30. I feel the digital library is efficient.	3.544	0.882	-0.122	-0.104
SU4		31. I feel the digital library is effective.	3.569	0.915	-0.143	-0.177

Table 13

Cronbach's Alpha Values for the Scales/Constructs in Study Instrument

Items (Variables)	Scale/Construct	Cronbach's Alpha
1-4 (CT1- CT4)	Content	0.885
5-6 (TI1-TI2)	Timeliness	0.894
7-11 (YQ1- YQ5)	System Quality	0.916
12-14 (IT1- IT3)	Intrinsic Interest	0.487
15-17 (CL1- CL3)	Control	0.200
18-20 (SQ1- SQ3)	Service Quality	0.390
21-24 (IU1- IU4)	Use (intension to use)	0.901
25-27 (SA1- SA3)	User Satisfaction	0.754
28-31 (SU1- SU4)	User Success	0.927

While Cronbach's alpha value for the study instrument as a whole (all items combined) was 0.90, most of the scales had alpha values well above the satisfactory value of 0.70 (DeVellis, 1991; Spector, 1992). Those scales with low alpha values had an item worded in a negative sense relative to the other items in the scale (e.g. Item IT1 in the Intrinsic Interest scale), even though I reverse-coded their values before computing alpha values. These low Cronbach's alpha values were considered a major concern even though previous studies that have used the items have already consistently validated their internal consistency (e.g. DeLone & McLean, 2003; Jung, 1997) and despite the fact that, for exploratory studies such as this, alpha values as low as 0.6 are considered acceptable though not desirable (DeVellis, 1991).

In order to improve the internal consistency (reliability) of some of the scales with low alpha values, items that contributed the most to the improvement of alpha values when deleted (or those that contributed to the low alpha values when added) were

dropped. For instance, dropping Item IT1 from the Intrinsic Interest scale increased the alpha value by 0.285 while dropping Item CL2 from the Control scale increased the alpha value from 0.200 to 0.780. Similar instance, while dropping Item SQ2 from the Service Quality scale increased the alpha value from 0.390 to 0.851 and dropping Item SA3 from the User Satisfaction scale increased the alpha value from 0.754 to 0.90. Dropping the last item may not seem to have contributed a lot in terms of the reduction in the alpha value but it was also evident from the exploratory factor analysis that the factor loading for Item SA3 was less than adequate and thus threatening the construct validity of the scale for User Satisfaction. On top of contributing to the low internal consistency of the scales, these dropped items had either a non-significant or not so significant correlations with items from the same scale. This could have had an effect on the construct validity of the original sets of items and thus creates an additional reason for dropping them. Table 14 below presents the final list of items and scales together with their recalculated alpha values.

Table 14

Recalculated Cronbach's Alpha Values for the Scales/Constructs in the Study Instrument

Items (Variables)	Scale/Construct	Cronbach's Alpha
1-4 (CT1- CT4)	Content	0.885
5-6 (TI1-TI2)	Timeliness	0. 894
7, 9-11 (YQ1, YQ3 - YQ5)	System Quality	0. 916
13-14 (IT2- IT3)	Intrinsic Interest	0.772
15, 17 (CL1, CL3)	Control	0.780
18,20 (SQ1, SQ3)	Service Quality	0.851
21-24 (IU1- IU4)	Use (intension to use)	0. 901
25-26 (SA1- SA2)	User Satisfaction	0.900
28-31 (SU1- SU4)	User Success	0. 927

In general, validity refers to an instrument's scientific utility and an instrument is valid to the extent, as mentioned earlier that "it measures what it purports to measure" (Nunnally & Bernstein, 1994, p. 83). One of the types of validity, construct validity, is an indicator of how well an item actually measures the construct it was designed to measure (Netemeyer, Bearden, & Sharma, 2003). The construct validity of an instrument is evaluated by looking at intercorrelations among items measuring the same construct. If items that relate to a construct are at least moderately correlated, they are considered to have construct validity. Factor and correlation analyses are often used to determine the construct (convergent and discriminant) validity and they were employed to assess the study instrument.

The two main types of construct validity namely convergent and discriminant validity were used to assess the construct validity of the study instrument. Items in an instrument have convergent validity if they measure the same construct and they are highly correlated. They are said to have discriminant validity if they measure closely related but conceptually different constructs and groups of items measuring a particular such construct have a low to moderate correlation with groups of items measuring the conceptually different construct (Netemeyer, Bearden, & Sharma, 2003).

All subsequent analyses were based on the remaining items in the instrument after items that contributed to low alpha values and those that had either non-significant or not very significant correlations with items from the same scale were deleted.

Table 15

Correlations among Items in the Study Instrument

	CT2	CT3	CT4	TI1	TI2	YQ1	YQ2	YQ3	YQ4	YQ5	IT2	IT3	CL1	CL3	SQ1	SQ3	IU1	IU2	IU3	IU4	SA1	SA2	SU1	SU2	SU3	SU4
CT1	.702**	.621**	.667**	.204**	.135*	.136*	.118	.147*	.135*	.065	.095	.002	-.026	.111	.096	.008	.315**	.403**	.345**	.381**	.302**	.232**	.470**	.322**	.333**	.465**
CT2		.776**	.648**	.210**	.170*	.157*	.104	.133*	.202**	.126	.129	-.015	.019	.172*	.170*	.101	.337**	.373**	.325**	.350**	.211**	.155*	.397**	.378**	.331**	.394**
CT3			.560**	.088	.082	.124	-.001	.133*	.098	.063	.088	.024	.035	.157*	.194**	.059	.287**	.327**	.315**	.368**	.247**	.210**	.412**	.306**	.282**	.396**
CT4				.259**	.260**	.209**	.130	.133*	.209**	.189**	.046	.013	.033	.054	.176*	.137*	.253**	.355**	.236**	.377**	.175*	.163*	.445**	.285**	.336**	.463**
TI1					.808**	.525**	.396**	.421**	.384**	.392**	.087	.028	.213**	.218**	.353**	.410**	.233**	.313**	.211**	.243**	.212**	.227**	.325**	.281**	.286**	.249**
TI2						.435**	.370**	.409**	.393**	.395**	.101	.080	.179*	.111	.384**	.409**	.224**	.314**	.237**	.254**	.227**	.280**	.234**	.226**	.167*	.205**
YQ1							.597**	.802**	.776**	.710**	.231**	.137*	.235**	.274**	.352**	.342**	.310**	.299**	.179*	.303**	.229**	.222**	.349**	.321**	.348**	.347**
YQ2								.614**	.680**	.509**	.152*	.086	.103	.202**	.248**	.234**	.226**	.258**	.258**	.175*	.161*	.150*	.273**	.190**	.279**	.192**
YQ3									.771**	.710**	.233**	.113	.229**	.242**	.207**	.190**	.230**	.251**	.246**	.236**	.273**	.233**	.321**	.240**	.282**	.299**
YQ4										.715**	.215**	.172*	.241**	.310**	.278**	.317**	.328**	.330**	.265**	.315**	.175*	.133*	.286**	.234**	.253**	.251**
YQ5											.146*	.068	.126	.245**	.304**	.276**	.195**	.267**	.184**	.224**	.247**	.225**	.253**	.257**	.269**	.253**
IT2												.629**	.365**	.278**	.169*	.160*	.275**	.220**	.116	.203**	.025	.121	.193**	.228**	.224**	.192**
IT3													.308**	.324**	.145*	.134*	.270**	.169*	.087	.138*	.089	.109	.068	.090	.100	.118
CL1													.640**	.286**	.335**	.206**	.174*	.089	.162*	.143*	.220**	.109	.138*	.123	.110	
CL3														.328**	.295**	.296**	.239**	.219**	.244**	.219**	.268**	.239**	.208**	.244**	.167*	
SQ1															.741**	.354**	.423**	.353**	.309**	.302**	.404**	.275**	.364**	.348**	.340**	
SQ3																.267**	.315**	.200**	.233**	.268**	.373**	.190**	.304**	.277**	.236**	
IU1																	.718**	.660**	.726**	.341**	.339**	.530**	.526**	.562**	.510**	
IU2																		.744**	.737**	.255**	.277**	.546**	.469**	.470**	.558**	
IU3																			.623**	.312**	.340**	.498**	.407**	.437**	.437**	
IU4																				.304**	.314**	.553**	.494**	.522**	.578**	
SA1																					.818**	.321**	.373**	.399**	.342**
SA2																						.305**	.333**	.312**	.321**	
SU1																							.708**	.785**	.762**	
SU2																								.772**	.747**	
SU3																									.791**	
SU4																										

Note. $^{**}p < 0.01$ (one-tailed), $^{*}p < 0.05$ (one-tailed)

As it is clear from Table 15, all correlation coefficients are significant ($p < .01$) for pairs of items in the same scale (measuring the same construct) which is an indication of their convergent validity. In addition to that, correlation coefficients for pairs of items from two different scales are mostly either not significant or, even those that are significant, less than the coefficients for pairs of items from the same scale. This is usually the case where the constructs being measured by the items (scales) have some relationships and thus creates the significant correlation between items from different scales. In spite of this, there is enough evidence to conclude that the items in the study instrument also have good discriminant validity. According to a similar method of assessing discriminant validity which is counting the number of times an item in a scale has a higher correlation with items in the instrument that are not measures of the same construct, an item has good discriminant validity if this count is less than half of the total number of possible comparisons in the instrument. All the 27 remaining items in the study instrument satisfy this criterion. Therefore, we can safely conclude that all scales/constructs have good construct (both convergent and discriminant) validity.

Exploratory Factor Analysis

Simply stated, factor analysis is a set of statistical techniques used to identify groups of related variables called factors. Usually there is a high correlation among variables within a group and low correlation between variables in different groups to satisfy convergent and discriminant validity requirements of items used to measure these variables (Nunnally & Bernstein, 1994). This makes factor analysis an appropriate tool for not only identifying which items in an instrument measure which

constructs/factors (exploratory factor analysis, EFA) but also for assessing the (construct, convergent, and discriminant) validity of the items (measures). It is an ideal tool for testing hypothesized measurement models (confirmatory factor analysis, CFA) that depict (define), a priori, the relationships items (measures) and factors have as well (Netemeyer, Bearden, & Sharma, 2003; Nunnally & Bernstein, 1994).

Factor analysis is conducted when a construct (factor) is latent, can not be measured directly, and requires more than one measure, that is, when a construct (factor) is a combination of two or more observable variables (measures). In other words, “the need for factor analysis arises because no single physical measure suffices” (Nunnally & Bernstein, 1994, p. 449). There are three different interpretations of factors as combinations of observable variables (measures). In this study, I followed the “effect indicators” interpretation where the observed variables (measures) are the effects (results, outcomes) of the factor (Nunnally & Bernstein, 1994). For instance, the dependent latent construct in the proposed comprehensive plus model, user success in digital library (see Figure 6), has four measures (Items 28 to 31 in Appendix B) that are possible effects (results, outcomes) of user success.

Exploratory factor analysis (EFA) can be used to identify the underlying structure (including common factors) and relationships among a set of observable variables (measure) (Netemeyer, Bearden, & Sharma, 2003). The “common factor analysis” approaches to exploratory factor analysis were used in this study where the main goal is to identify the latent constructs in the comprehensive plus model based on the correlations among the measures (items in the study instrument). The exploratory factor analysis involved all the remaining 27 items in the study instrument (after deletion of

those that contributed to low alpha values) using LISREL (version 8.80). One of the most used procedures in factor analysis to extract common factors, principal component analysis, together with the varimax rotation technique was utilized. In order to check the adequacy of factor extraction, factors having eigenvalues less than 1.0 were eliminated.

Table 16

Exploratory Factor Analysis Results

Item/Variable		Factor								
		1	2	3	4	5	6	7	8	9
Content	CT1	0.038	0.188	**0.821**	0.194	0.152	-0.128	0.076	0.016	-0.021
	CT2	0.066	0.153	**0.860**	0.160	0.016	0.051	0.040	0.005	0.057
	CT3	0.004	0.131	**0.814**	0.161	0.102	0.055	-0.075	0.004	0.080
	CT4	0.100	0.192	**0.814**	0.087	-0.013	0.092	0.156	0.003	-0.064
Timeliness	TI1	0.321	0.161	0.101	0.077	0.046	0.139	**0.860**	-0.037	0.133
	TI2	0.301	0.020	0.082	0.140	0.114	0.209	**0.855**	0.049	-0.015
System Quality	YQ1	**0.835**	0.205	0.067	0.053	0.042	0.137	0.186	0.077	0.118
	YQ2	**0.767**	0.068	-0.003	0.147	0.019	0.051	0.141	0.031	-0.017
	YQ3	**0.868**	0.125	0.054	0.067	0.135	-0.061	0.131	0.073	0.113
	YQ4	**0.881**	0.039	0.095	0.184	-0.028	0.108	0.064	0.082	0.131
	YQ5	**0.814**	0.113	0.042	0.035	0.106	0.153	0.091	0.003	0.025
Intrinsic Interest	IT2	0.133	0.146	0.050	0.067	-0.031	0.044	0.009	**0.870**	0.166
	IT3	0.050	-0.007	-0.030	0.108	0.061	0.045	0.002	**0.876**	0.151
Control	CL1	0.088	0.036	-0.029	0.040	0.055	0.151	0.107	0.220	**0.859**
	CL3	0.180	0.080	0.074	0.142	0.108	0.115	-0.009	0.130	**0.838**
Service Quality	SQ1	0.163	0.158	0.072	0.219	0.154	**0.837**	0.120	0.053	0.132
	SQ3	0.164	0.118	-0.003	0.091	0.132	**0.850**	0.207	0.055	0.169
Use (Intention to use)	IU1	0.125	0.321	0.122	**0.764**	0.130	0.088	0.036	0.184	0.118
	IU2	0.152	0.247	0.231	**0.790**	0.019	0.181	0.125	0.086	0.048
	IU3	0.121	0.166	0.156	**0.833**	0.156	0.073	0.044	-0.025	0.025
	IU4	0.122	0.321	0.232	**0.753**	0.080	0.058	0.070	0.065	0.086
User Satisfaction	SA1	0.133	0.205	0.133	0.132	**0.905**	0.069	0.051	-0.013	0.064
	SA2	0.083	0.136	0.089	0.166	**0.880**	0.211	0.094	0.053	0.109
User Success	SU1	0.178	**0.750**	0.294	0.315	0.082	-0.022	0.108	0.013	0.074
	SU2	0.108	**0.826**	0.148	0.217	0.137	0.164	0.071	0.064	0.049
	SU3	0.166	**0.852**	0.138	0.251	0.133	0.098	0.028	0.050	0.060
	SU4	0.142	**0.793**	0.301	0.268	0.102	0.100	0.033	0.070	-0.008

Using the above mentioned criteria, that is by retaining factors having eigenvalues greater than 1.0, the nine (9) different factors were clearly identified and their respective items had factor loadings of 0.767 and higher. I decided to consider this the cut-off value to disqualify items for being considered measures of the other factors they were not meant to measure even though the traditional cut-off value is 0.5 (Hair et al., 1998). As is evident from Table 16 below, a clear factor structure that emerged for the nine (9) factors is another indication of the construct (i.e. both convergent & discriminant) validity of the study instrument.

Confirmatory Factor Analysis

Confirmatory factor analysis is useful when the relationships between variables are defined in a measurement model and this definition is based on strong theory and previous research (Nunnally & Bernstein, 1994). It is used mainly to test a specified theoretical factor structure to determine the degree of the factor structure "fit" with "observed covariances among the items in the factor(s)" (Netemeyer, Bearden, & Sharma, 2003, p. 148). One of the methods commonly used for confirmatory factor analysis is structural equation modeling (SEM). Structural equation modeling is a family of statistical techniques that include path analysis, factor analysis, regression analysis, and structure (covariance structure) analysis (Schumacker & Lomax, 2004). Path analysis is mainly used to estimate the direct/indirect effects of independent variables on dependent variables and factor analysis is used, among other things, to test how well a set of observed variables measure latent constructs and test measurement models. The most widely used procedure among SEM techniques is structure (covariance

structure) analysis which makes the study of the relationships between latent constructs possible. It is attractive to researchers perhaps because it provides a single comprehensive means for testing complex theoretical models' fit to sample data.

In addition to confirmatory factor analysis, in this dissertation structure (covariance structure) analysis was used to test two models and answer the two research questions. A typical structural equation model is composed of measurement and structural models (Schumacker & Lomax, 2004). A measurement model specifies the relationships between the measures (observed variables or items in the instrument) and the latent constructs, whereas the structural model specifies the nature of the relationships between the latent constructs.

As a confirmatory factor analysis tool, structural equation modeling enables one to empirically validate hypothesized models and to confirm or disconfirm previous theory. A typical structural equation model analysis meant as a confirmatory factor analysis estimates a number of parameters of a hypothesized model using a sample covariance matrix (calculated based on measures of the constructs). In addition to that, it also determines the fit of the hypothesized model to the sample data. In this case, it compares the sample covariance matrix (calculated based on measures of the constructs) to the estimated covariance matrix and based on this comparison if the two covariance matrices are not that far apart, then the hypothesized model is said to fit the sample data. The degree or goodness of fit of the hypothesized model to the sample data is assessed using a number of indicators out of which there is no single best indicator. As a result, a combination of the various indicators is used to determine the fit.

These indicators of model fit are divided into three main groups, namely indicators of overall fit, comparative fit, and parsimonious fit. Literature suggested that among these three, the first two indicators are widely used (Tanaka, 1993). Indicators of absolute fit are measures of the ability of the model to reproduce the original sample covariance matrix. On the other hand, indicators of comparative fit compare the hypothesized model with other competing models to see whether the hypothesized model fits to the data better than these competing models (Kelloway, 1998).

Absolute Fit

As stated earlier, indicators of absolute fit measure the ability of the hypothesized model to reproduce the sample or original covariance matrix. Perhaps the most often indicator reported in the literature is the χ^2 test statistic. A non significant χ^2 is a sign of non significant difference between the sample/original covariance matrix and the one implied by the hypothesized model. What necessitated the need for measures of absolute fit other than the χ^2 statistic is the fact that a χ^2 distribution requires a large sample and χ^2 values are dependent on the sample size. As the sample size increases, χ^2 values increase and thus making it difficult to achieve a non significant test statistic which is a requirement for model fit.

In order to address this issue, other indicators of absolute fit were introduced. Most structural equation modeling software including LISREL which was used for this dissertation produce values of most of these indicators. These are: the root mean square residual (RMR), root mean square error of approximation (RMSEA), the goodness-of-fit index (GFI), and the adjusted goodness-of-fit index (AGFI).

The Root Mean Square Residual (RMR)

This is the square root of the mean of the squared differences (residuals) between the sample or original covariance matrix and the covariance matrix implied by the hypothesized model. It is a measure of the mean difference between the sample or original covariance matrix and the covariance matrix implied by the hypothesized model. The closer the value of this measure is to 0, the better the goodness of fit of the hypothesized model to sample data. Because of its sensitive nature to the scale of measurements of the constructs in the hypothesized model, a standardized form of the root mean square residual namely the standardized RMR is often used instead. A standardized RMR value of 0.05 or less is considered an indication of good fit of the hypothesized model to sample data (Kelloway, 1998).

The Root Mean Square Error of Approximation (RMSEA)

This is a "measure of discrepancy per degree of freedom" (Jöreskog, 1993, p. 310). It is similar to the RMR in that it is based on the residuals where smaller values are indicators of model fit to sample data. Values less than 0.10 are usually accepted as indications of good fit (Steiger, 1990).

The Goodness-of-Fit Index (GFI)

The goodness-of-fit index (GFI) was introduced to counter the χ^2 statistic and to eliminate the influence of sample size. Both the goodness-of-fit index (GFI) and the adjusted goodness-of-fit index (AGFI) discussed below, "do not depend on sample size explicitly and measure how much better the model fits compared with no model at all"

(Jöreskog, 1993, p. 309). It is the ratio of the sum of squared differences (residuals) between the sample or original covariance matrix and the covariance matrix implied by the hypothesized model to the observed variance. Its values range from 0 to 1 where values over 0.9 are considered indicators of good model fit to sample data.

The Adjusted Goodness-of-Fit Index (AGFI)

This is the goodness-of-fit index (GFI) adjusted for degrees of freedom. Similar to the GFI, the AGFI ranges from 0 to 1 and the higher the value the better the model fit to sample data. Acceptable values are usually above 0.9.

Comparitive Fit

Like absolute fit, comparative fit assesses the degree to which the hypothesized model fits sample data. Comparative fit is concerned with whether the hypothesized model is better than other competing models. Indicators of comparative fit compare the hypothesized model with the baseline model which is usually a null model which specifies no relationships between the constructs in the hypothesized model. A separate set of indicators have also been introduced to assess comparative fit. Like the absolute fit indicators, most of the structural equation modeling software such as LISREL produces values of indicators of comparative fit. These indicators include: the normed fit index (NFI), the non-normed fit index (NNFI), the comparative fit index (CFI), the incremental fit index (IFI), and the relative fit index (RFI).

The Normed Fit Index (NFI)

The normed fit index (NFI), proposed by Bentler and Bonett (1980) measures the percentage improvement in fit of the hypothesized model over the baseline independence model. It computed using the formula (χ^2 null model - χ^2 hypothesized model)/ χ^2 null model. Values of the NFI range between 0 and 1 and values greater than 0.9 are indicators of a good fit.

The Non-Normed Fit Index (NNFI)

This is the normed fit index (NFI) adjusted for the number of degrees of freedom. Unlike values of the NFI, values of the non-normed fit index (NNFI) may sometimes be outside the range between 0 and 1 even though higher values of the NNFI are also indicators of a good value where 0.9 is the cut-off value.

The Comparative Fit Index (CFI)

The comparative fit index, proposed by Bentler (1990) is computed using ((χ^2 – df) null model - (χ^2 – df) hypothesized model)/ (χ^2 – df) null model (where df stands for the number of degrees of freedom). It takes the sample size into account and its values range between 0 and 1, with values exceeding 0.90 indicating a good fit of the hypothesized model to sample data.

The Incremental Fit Index (IFI)

Proposed by Bollen (1989), the incremental fit index (IFI) is computed using the formula (χ^2 null model - χ^2 hypothesized model)/ (χ^2 null model – df hypothesized

model). Values of the incremental fit index range between 0 and 1 where values closer to 1 are indications of a good fit of the hypothesized model to sample data.

The Relative Fit Index (RFI)

The relative fit index (RFI) is a derivative of the normed fit index (NFI). As stated earlier, its values range between 0 and 1 with values that are greater than 0.90 as indicators of a good fit.

Summary

In general a hypothesized model has a good fit to sample data if at least two of the indicators satisfy the minimum (or maximum) criterion. Some of these are: a non-significant χ^2 and a *p*-value > 0.05 (sometimes even > 0.10 or 0.20); a root mean square residual (RMR) and root mean square error of approximation (RMSEA) as high as 0.08; a goodness-of-fit index (GFI), and adjusted goodness-of-fit index (AGFI), a normed fit index (NFI), a non-normed fit index (NNFI), a comparative fit index (CFI), a incremental fit index (IFI), and a relative fit index (RFI) is ≥ 0.90.

Table 17

Model Fit Statistics for Measurement Models of the Comprehensive DLUS and the Proposed Model

Measurement Model	χ^2	*df*	*p*	RMSEA	RMR	GFI	AGFI	NFI	NNFI	CFI	IFI	RFI
Comprehensive DLUS (*constructs & items:* Content (CT1-CT4), Intrinsic Interest (IT2-IT3), Control (CL1, CL3), Timeliness (TI1-TI2))	108.69	68	.0013	.061	.039	.911	.862	.932	.959	.970	.970	.909
Proposed model (*constructs & items:* Content (CT1-CT4), Intrinsic Interest (IT2-IT3), Control (CL1, CL3), Timeliness (TI1-TI2), System Quality (YQ1-YQ5), Service Quality (SQ1, SQ3), Use(Intention to use) (IU1-IU4), User Satisfaction (SA1-SA2), User Success (SU1-SU4))	464.53	288	.00	.062	.04	.822	.766	.919	.955	.963	.963	.901

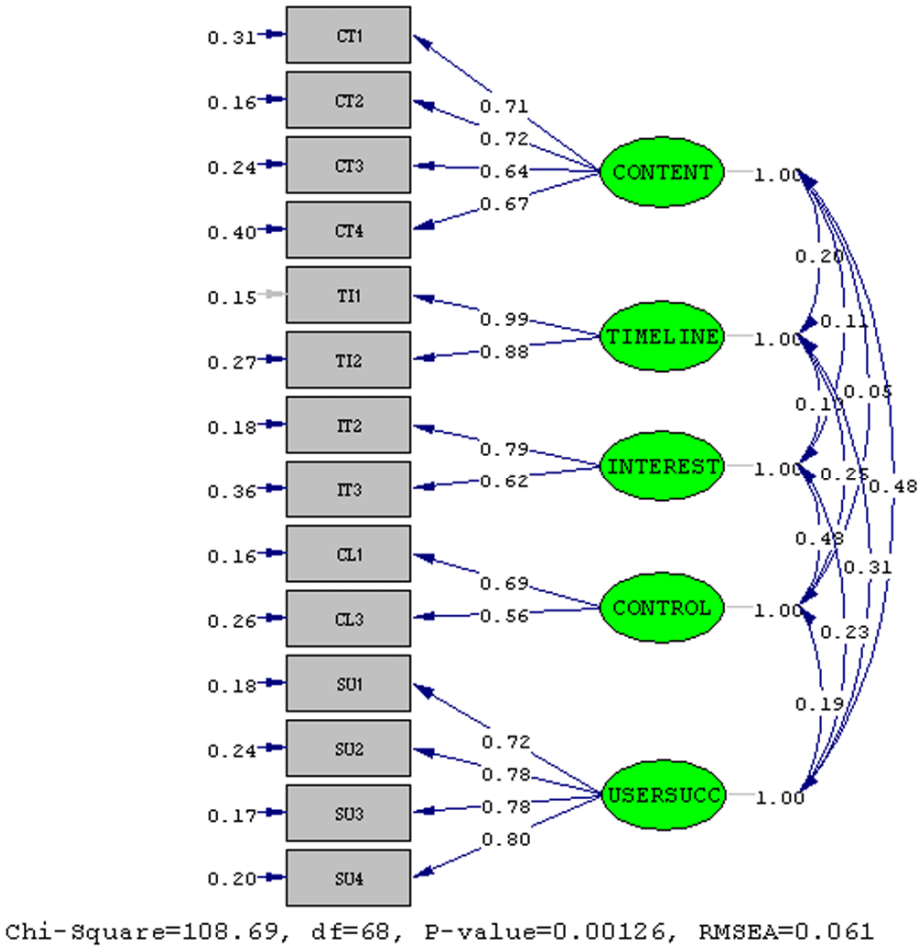


Figure 8. Measurement model for the comprehensive DLUS model.

Based on the exploratory factor analysis conducted earlier, the 27 items in the instrument that loaded on their respective scales were subjected to confirmatory factor analysis using LISREL. Any structural analysis of latent constructs should be preceded by the assessment of the fit of the relevant measurement model to sample data. In order to establish this fact, a measurement model for each of the two models namely the comprehensive DLUS and the proposed user success model in a digital library was specified and submitted to LISREL. Model fit was assessed using the indicators discussed above. On top of this, loadings of the items onto their respective scales were

closely examined to see if results confirm those obtained from the exploratory factor analysis in Table 16. Table 17 is a summary of the values of the indicators of model fit for the two measurement models.

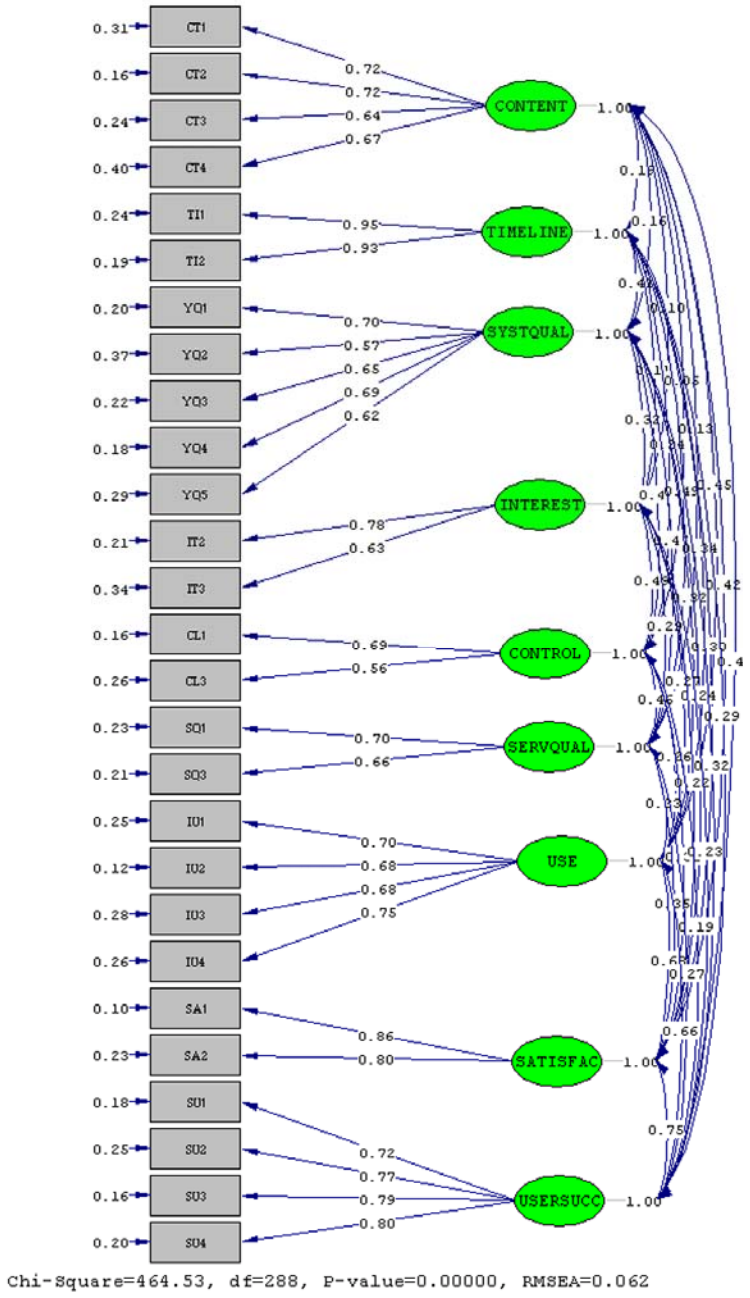


Figure 9. Measurement model for the proposed model.

It is clear from Table 17 and Figures 8 and 9 that the two measurement models fit the sample data well as evidenced by the fact that values of at least seven (7) of the 10 indicators of model fit are either less than the often recommended maximum values or they are greater than the recommended minimum values. In addition to that, a review of Figures 8 and 9 and the LISREL output revealed that the loadings of the individual items on their respective constructs/scales are statistically significant with reasonably low error terms and thus confirming the results from the exploratory factor analysis including the construct validity of the scales.

Assessment of the Comprehensive Digital Library User Success Model (DLUS) (RQ1)

The first research question posed was: To what extent does the comprehensive digital library user success model (DLUS), based on a combination of the EUCS and flow models, describe overall user success in a prototype digital library environment? In order to answer this research question, I used structural equation modeling using LISREL. As discussed earlier, structural equation modeling is a set of techniques one of which is structure (covariance structure) analysis. It is often used to test complex models with latent variables including their relationships. A theoretical model usually consists one or more dependent latent constructs and a number of independent latent constructs. Whether the model explains or describes the dependent latent construct given the independent latent constructs and their relationships with the dependent latent construct and amongst themselves is one of the questions that could be answered with the help of structural equation modeling, specifically through the evaluation of model fit indicators.

The comprehensive digital library user success model (DLUS) consists of four (4) independent and one (1) dependent latent constructs. The four independent latent constructs are content, intrinsic interest, control, and timeliness while the dependent latent construct is user success. The four independent latent constructs were hypothesized to have some effect on the dependent latent construct and as predictors of user success (Jung, 1997). A LISREL analysis with the comprehensive digital library user success model and the covariance matrix for items measure the five latent constructs as inputs produced results presented in Figure 10 and Table 18.

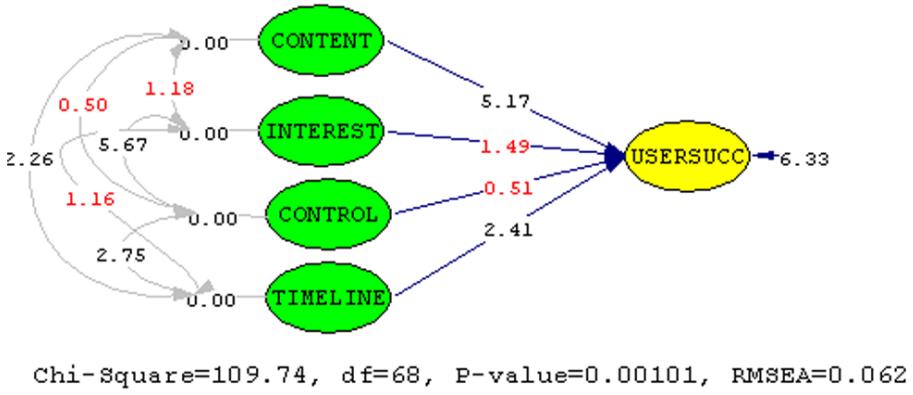


Figure 10. Structural model of the comprehensive DLUS.

Table 18

Standardized Path Coefficients and Fit Statistics for the Comprehensive DLUS Model

Path	Standardized Coefficient	*t*-Value
Content → User Success	0.43	5.17*
Intrinsic interest → User Success	0.14	1.49
Control → User Success	0.05	0.51
Timeliness → User Success	0.20	2.41*
R^2=0.31		
Model Fit Statistics: χ^2 =109.74, *df*=68, *p*=0.001, RMSEA=0.062, RMR=0.04, GFI=0.910, AGFI=0.861, NFI=0.932, NNFI=0.958, CFI=0.969, IFI=0.969, RFI=0.908		

*$p < 0.05$

The model fit indicators show that the comprehensive DLUS model as originally specified fits the sample data well. Eight (8) of the 10 indicators are either less than the often recommended maximum values (for instance RMR and RMSEA values are < 0.08) or they are greater than the recommended minimum values (all except AGFI are > 0.90). However before we conclude that the model explains the latent dependent variable (user success), the path coefficients between the independent latent variables and the dependent latent variable need to be examined. An examination of the path coefficients shows that while two of the independent latent variables namely content and timeliness have significant relationships ($p < 0.05$) with the dependent variable (user success) but the other two namely intrinsic interest and control do not. Between the two independent latent variables that have significant relationships with the dependent latent variable, content is the better predictor of user success. Therefore while we obtained support for the comprehensive DLUS model due to its fit to the sample data, half of the independent latent variables were found to be very weak predictors of user success (the dependent latent variable). In order for us to conclude that the comprehensive DLUS model explains user success in a digital library, we should be able to obtain results that show the good model fit as well as path coefficients that are significant and in the hypothesized directions. This fact prompted us to conclude that for our sample data the comprehensive DLUS model does not fully explain user success in a prototype digital library environment. While we can not determine the reasons for this based on our sample data, one should look into the role the prototype digital library environment played. For instance, the interface of the prototype digital library was not well refined which may have lead to intrinsic interest

being a weak predictor of user success. In addition, the prototype digital library was not in production and thus not widely advertised and marketed within the UT Dallas community and thus not used very much in the data collection period. In addition to this, there were no regular training for users specifically on the use of the prototype digital library which may result in lack of experience/expertise on the part of the users so that the independent latent variable control was a weak predictor of user success.

Assessment of the Proposed User Success Model (RQ2)

The second research question posed was: To what extent does a combined model of DeLone & McLean's reformulated information system success model and comprehensive digital library user success model (DLUS) explain digital library user success in a prototype digital library environment? Once again, structural equation modeling using LISREL was utilized to fit the proposed model (the comprehensive plus model of user success) in a digital library environment to sample data. The model has six (6) independent latent variables and three (3) dependent latent variables with 'User Success' as the dependent latent variable where the other two dependent latent variables ('Use' and 'User Satisfaction') are intermediaries between the six independent latent variables and User Success.

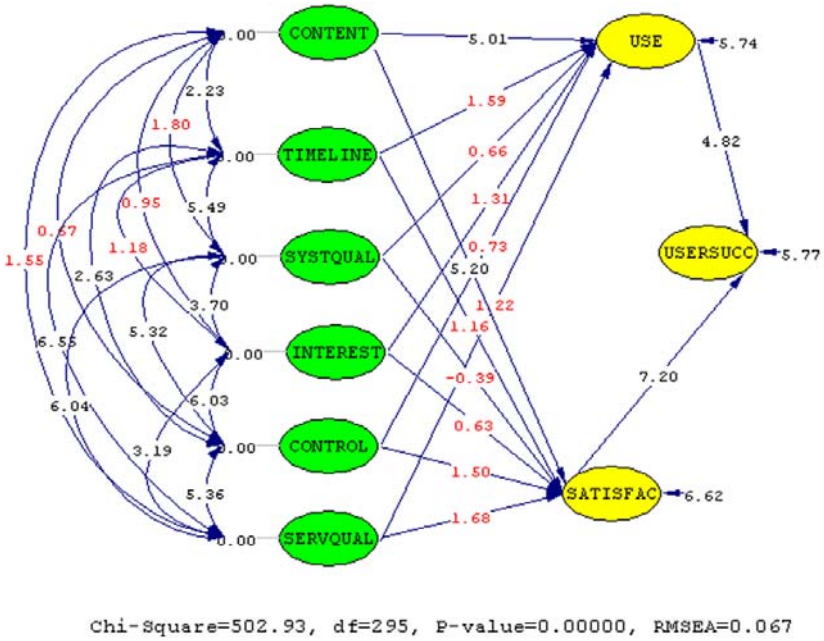


Figure 11. Structural model of the proposed model.

Table 19

Standardized Path Coefficients and Fit Statistics for the Proposed Model

Path	Standardized Coefficient	*t*-Value
Content → Use	0.41	5.01*
Timeliness → Use	0.15	1.59
System Quality → Use	0.06	0.66
Intrinsic interest → Use	0.13	1.31
Control → Use	0.08	0.73
Service Quality → Use	-0.04	1.22
Content → User Satisfaction	0.41	5.20*
Timeliness → User Satisfaction	0.11	1.16
System Quality → User Satisfaction	-0.04	-0.39
Intrinsic interest → User Satisfaction	0.06	0.63
Control → User Satisfaction	0.16	1.50
Service Quality → User Satisfaction	0.18	1.68
Use → User Success	0.35	4.82*
User Satisfaction → User Success	0.56	7.20*
R^2=0.565		
Model Fit Statistics: χ^2 =502.93, *df*=295, *p*=0.00, RMSEA=0.067, RMR=0.055, GFI=0.810, AGFI=0.757, NFI=0.912, NNFI=0.949, CFI=0.957, IFI=0.957, RFI=0.895		

*$p < 0.05$

The proposed model represents a good fit based on the model fit statistics (Figure 11 & Table 19). The root mean square error of approximation (RMSEA) and the root mean square residual values are both below the maximum limit of 0.08. Even though the goodness-of-fit index (GFI) and the adjusted goodness-of-fit index (AGFI) values are below the recommended value of 0.90, all except one (RFI) of the indicators of comparative fit (NFI, NNFI, CFI, IFI) are above the cut-off value of 0.90. The problem with the proposed model is the large number of non-significant path coefficients. As stated earlier, path coefficients determine whether or not significant correlations exist between latent variables in a structural model. In the proposed model all the relationships between the latent variables are hypothesized and are expected to be positive and significant. However, only the relationships between one of the six independent latent variables (Content) and two dependent latent variables (Use and User Satisfaction) as well as the relationships between two of the dependent latent variables (Use and User Satisfaction) and User Success were statistically significant as evidenced by significant *t*-values ($p < 0.05$).

Once again, it is difficult to pinpoint the reasons for lack of relationships between Timeliness, System Quality, Intrinsic Interest, Control and Service Quality on one hand, and Use and User Satisfaction on the other. One may speculate that the prototype nature of the digital library and lack of training as well as marketing have contributed to some extent. The lack of significant relationships between the latent constructs makes the decision difficult to accept the model as valid but the fact that the model fit statistics indicate that the model fit the sample data well. This situation prompted further actions instead of making any conclusions based on the above results.

When either a model is found to not fit sample data or when the relationships between latent variables hypothesized according to a previous theory are not supported, literature suggests the best course of action is model modification. Model modification is an exercise to see if a modified model satisfies both the criteria, i.e. fits sample data and relationships between latent variables are significant and the model explains or describes the main dependent latent construct. Another goal of model modification is to improve what is known as model parsimony. A model modification exercise usually involves either deletion of non-significant paths from the model or addition of paths to the model and its goal is to specify and generate a new and more appropriate model using available information and sample data (Kelloway, 1998).

The exercise of model modification is more of exploratory rather than confirmatory in nature. The new and modified model should have some sort of theoretical support where the relationships between the latent variables are supported by previous theory. As discussed in detail in Chapter 2, the six independent latent variables and the three dependent latent variables in the proposed comprehensive plus model as well as their relationships was grounded in previous research and literature. So, a modified version of the proposed model (Figure 12 and Table 20) was justified and produced. This model had a good fit to the sample data and the path coefficients are significant and positive ($p < 0.10$).

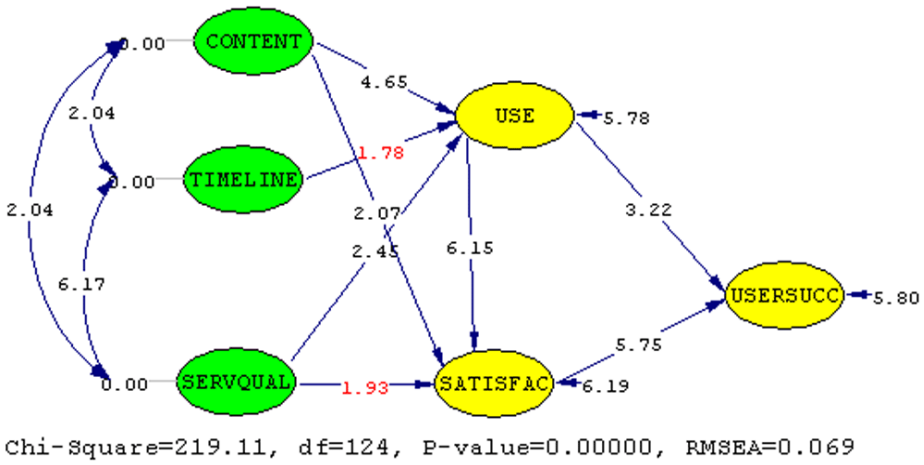


Figure 12. Structural model of the modified version of the proposed model.

Table 20

Standardized Path Coefficients and Fit Statistics for the Modified Version of the Proposed Model

Path	Standardized Coefficient	*t*-Value
Content → Use	0.39	4.65**
Timeliness → Use	0.16	1.78*
Service Quality → Use	0.23	2.45**
Content → User Satisfaction	0.16	2.07**
Service Quality → User Satisfaction	0.15	1.93*
Use → User Satisfaction	0.55	6.15**
Use → User Success	0.29	3.22**
User Satisfaction → User Success	0.55	5.75**
R^2=0.606		
Model Fit Statistics: χ^2 =219.11, *df*=124, *p*=0.00, RMSEA=0.069, RMR=0.047, GFI=0.867, AGFI=0.817, NFI=0.945, NNFI=0.967, CFI=0.973, IFI=0.974, RFI=0.932		

**$p < 0.05$, *$p < 0.10$

While the original proposed model of user success in a digital library environment did not fully explain user success, the modified version of the proposed model did much better in terms of both model fit and relationships between latent variables. This was

achieved by deleting three (3) of the independent latent variables ('System Quality', 'Intrinsic Interest', & 'Control') that did not show any significant relationships with 'Use' and User Satisfaction. It is clear from Figure 10 and Table 20 that all except three of the model fit indicators did not meet either the minimum or maximum criteria.

The chi-square statistic, the goodness-of-fit index (GFI) and the adjusted goodness-of-fit index (AGFI) were the three indicators that did not meet the minimum or maximum criteria for a good model fit. On top of fitting the sample data well, the modified version of the proposed model has latent variables that have significant relationships ($p < 0.10$) as evidenced by significant path coefficients. In addition to that, there is an improvement in the R^2 value (0.565 versus 0.606) when compared to the original proposed model. Among the three independent latent variables dropped from the originally proposed model, 'System Quality' is perhaps a stronger candidate to be added to a future model. It is not justified to drop 'System Quality' based on results from a prototype digital library. Therefore even though we didn't find support for the original proposed model, the modified version of the comprehensive plus model of user success in a digital library environment (Figure 12) is proposed as a viable alternative (and with the addition of 'System Quality' as another independent latent variable) based on the results of this study.

Summary

This chapter presented data analysis results and findings of the current study. The study addressed two research questions related to two competing models of user success in a digital library environment. Characteristics of the participants and data

screening procedures were described together with results from the assessment of validity and reliability of the study instrument. In order to answer the research questions exploratory and confirmatory factor analyses as well as structural equation modeling using LISREL were conducted.

The first research question (RQ1) dealt with the extent to which the comprehensive digital library user success model (DLUS), based on a combination of the EUCS and flow model describe overall user success in a prototype digital library environment. I found support for the comprehensive DLUS model through examination of model fit statistics but failed to support the relationships between the latent variables hypothesized by the model.

The second research question (RQ2) dealt with the extent to which a combined model of the comprehensive DLUS (1997) and DeLone & McLean's (2003) reformulated information system success model called the comprehensive plus model, explain user success in a prototype digital library environment. Similar to results for the first research question, the proposed model fit sample data well but some of the relationships between latent variables were not significant. A modified version of the proposed model was then specified and tested. Model fit statistics confirmed the modified model's fit to sample data with all the relationships between the latent variables significant at 10% level of significance.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Introduction

This chapter presents summary of the findings of the study, its limitations, some conclusions and further interpretations based on results of data analyses and implications of the research findings. Finally, recommendations for future research efforts on the topic of user success in digital library environments are suggested.

Summary of the Findings

From the outset, the study reported in this dissertation was meant as an exploratory study of factors affecting user success in a digital library environment. The main goal of this dissertation was to both develop a conceptual model of user success in a digital library environment based on two previous models, namely Jung's (1997) and DeLone & McLean's (2003) models of user success and test the proposed combined model (the comprehensive plus model) as well as determine possible factors that can best predict user success in a digital library environment. In order to achieve this goal, two research questions were posed:

> RQ1. To what extent does the comprehensive digital library user success model (DLUS), based on a combination of the EUCS and flow models, describe overall user success in a prototype digital library environment?
>
> RQ2. To what extent does a combined model of the comprehensive DLUS (1997) and DeLone & McLean's (2003) reformulated information system success models explain digital library user success in a prototype digital library environment?

Data were collected from 191 users of a prototype digital library using a survey questionnaire that I had previously pilot tested. The survey questionnaire consisted of

31 relevant items that are measures of 9 constructs. With a student population of 14,000 during the 2005/6 academic year, around 6000 used the libraries and around 1700 visited and used the prototype digital library as revealed by the digital library usage log. Email addresses of 300 users were identified and used to solicit participation in the survey. After two rounds of emails each to two groups of the 300 users including follow up email messages to request them to complete a survey questionnaire, the total number of completed questionnaires was 191 for a response rate of 63.7%. Due to incompleteness, 31 completed questionnaires had to be discarded which reduced the final number of completed and usable questionnaires to 160. There were slightly more female (54.4%) than male (45.6%) participants which is an acceptable combination and one that is not far from the combination in the University's general student population. As expected, a significant number of the participants were undergraduates (63.75%). This is a reflection of the combination of the student body at UT Dallas and the highest level of education for more than half of the participants (52.5%) is high school diploma.

Data screening was conducted to test the normality, validity, and reliability of the instrument and sample data. The data satisfied the normality criterion and almost all the items have skewness and kurtosis values not significantly different from zero. Analysis of validity and reliability reduced the number of valid and reliable items to 27. Generally, the 27 final set of items in the instrument and the sample data showed very good internal consistency (reliability) as well as construct validity (both convergent and discriminant validity).

Cronbach's alpha value for the study instrument as a whole (all 31 original items combined) was 0.90 and most of the scales had alpha values well above the

satisfactory value of 0.70 (DeVellis, 1991; Spector, 1992). Some negatively worded items had to be deleted to improve alpha values for some of the scales. These same items contributed to lack of construct validity as evidenced by results of exploratory factor analysis.

Exploratory factor analysis (EFA) was used to identify the underlying structure and relationships among items in the instrument. The “common factor analysis” approach was utilized to extract the common factors through principal component analysis together with the varimax rotation technique. Exploratory factor analysis was used to identify the nine (9) latent constructs in the comprehensive plus model. All items had factor loadings of 0.767 and higher on their respective constructs and it was used as the cut-off value instead of the traditional cut-off value of 0.5 (Hair et al., 1998). Results of the exploratory factor analysis confirmed the good construct (i.e. both convergent & discriminant) validity of the study instrument.

Confirmatory factor analysis through structural equation modeling (SEM) enables one to empirically validate hypothesized measurement models of measures and latent variables as well as to determine the fit of the hypothesized measurement model to sample data. The degree or goodness of fit of the hypothesized model to the sample data is assessed using a number of indicators because there is no single best indicator. These indicators of model fit are indicators of overall (absolute) fit and comparative fit. The most often used indicator is the χ^2 test statistic which is dependent on the sample size. In order to address this, other indicators of absolute fit are used. Most structural equation modeling software such as LISREL provides values of most of these indicators as part of their outputs. While indicators of absolute model fit include the root mean

square residual (RMR), root mean square error of approximation (RMSEA), the goodness-of-fit index (GFI), and the adjusted goodness-of-fit index (AGFI), the comparative fit indicators include the normed fit index (NFI), the non-normed fit index (NNFI), the comparative fit index (CFI), the incremental fit index (IFI), and the relative fit index (RFI). Generally, a hypothesized model has a good fit to sample data if at least two of the indicators satisfy the minimum (or maximum) criterion. For instance, a model with a non-significant χ^2 and a *p*-value > 0.05; a root mean square residual (RMR) and root mean square error of approximation (RMSEA) as high as 0.08; a goodness-of-fit index (GFI), and adjusted goodness-of-fit index (AGFI), a normed fit index (NFI), a non-normed fit index (NNFI), a comparative fit index (CFI), a incremental fit index (IFI), and a relative fit index (RFI) ≥ 0.90, is accepted as a good fit to sample data.

In this dissertation, model fit was assessed using these indicators. In addition of the model fit indicators, item loadings onto their respective scales or latent variables is examined before a decision is made about whether the model fits the data or not. Two measurement models, one each for the two models of user success in a digital library environment namely the comprehensive DLUS and the proposed (or the comprehensive plus model) were tested using LISREL. Both measurement models fit the sample data well and values of at least seven (7) of the 10 indicators of model fit were either less than the often recommended maximum values or they were greater than the recommended minimum values. Results from the exploratory factor analysis and the construct validity of the scales in the instrument were confirmed as the loadings of individual items on their respective constructs/scales were statistically significant.

Assessment of the Comprehensive Digital Library User Success Model (DLUS) (RQ1)

The first research question dealt with the extent to which the comprehensive digital library user success model (DLUS), based on a combination of the EUCS and flow model explain user success in a prototype digital library environment. The comprehensive digital library user success model (DLUS) consists of four independent latent constructs (Content, Intrinsic Interest, Control, and Timeliness) and one dependent latent construct (User Success). The four independent latent constructs were hypothesized to have some effect on the dependent latent construct and as predictors of user success (Jung, 1997). Structural equation modeling using LISREL produced mixed results in terms of model fit and significance of path coefficients among latent variables.

An examination of the model fit indicators showed that the comprehensive DLUS model fits the sample data well as originally specified. The RMR and RMSEA values were under the often recommended maximum value of 0.08 while all the remaining indicators, except AGFI were above the often cited minimum value of 0.90. However, only the path coefficients between two of the independent latent variables, namely Content and Timeliness had significant relationships ($p < 0.05$) with the dependent variable (User Success) but Intrinsic Interest and Control were not found to be significant predictors of User Success. Even though the comprehensive DLUS model fit the sample data well but half of the independent latent variables were found to be very weak predictors of the dependent latent variable (User Success). I conclude, based on the current sample data, that the comprehensive DLUS model does not fully explain

user success in a prototype digital library environment. Possible reasons for this could be attributed to the nature of the prototype digital library environment such as the interface that was not well refined, lack of wider advertisement and use, and lack of regular training for users specifically on the use of the prototype digital library.

Assessment of the Proposed User Success Model (RQ2)

The second research question dealt with extent to which the proposed model (the comprehensive plus model), a combination of the DeLone & McLean's reformulated information system success model and the comprehensive digital library user success model (DLUS) explain user success in a prototype digital library environment. Similar to the first research question, structural equation modeling through LISREL was utilized to fit the proposed model to sample data. The proposed model had six (6) independent latent variables and three (3) dependent latent variables. The model fit statistics (χ^2 =502.93, *df*=295, *p*=0.00, RMSEA=0.067, RMR=0.055, GFI=0.810, AGFI=0.757, NFI=0.912, NNFI=0.949, CFI=0.957, IFI=0.957, RFI=0.895) show that the model fit sample data with R^2=0.565.

However, there are a large number of non-significant path coefficients which are indicators of lack of correlations between latent variables in the structural model. Only the paths from Content to Use, and User Satisfaction as well as the paths from Use and User Satisfaction to User Success were statistically significant ($p < 0.05$). The path coefficients from Timeliness, System Quality, Intrinsic Interest, Control and Service Quality to both Use and User Satisfaction were not significant as well. I can only speculate as to the reasons for this. Some of the reasons are the prototype nature of

the digital library and lack of training by users as well as marketing. Based on these results, I could not make any conclusions. Instead, when either a model is found to not fit sample data or when the relationships between latent variables hypothesized according to a previous theory are not supported the best course of action is model modification through deletion of non-significant paths from the model or addition of paths to the model (Kelloway, 1998).

In a model modification exercise which is exploratory in nature, the new and modified model as well as the relationships between the latent variables should have some theoretical support. A modified version of the proposed model was specified and using LISREL, analysis of the output showed that the model had a good fit to the sample data (χ^2 =219.11, *df*=124, *p*=0.00, RMSEA=0.069, RMR=0.047, GFI=0.867, AGFI=0.817, NFI=0.945, NNFI=0.967, CFI=0.973, IFI=0.974, RFI=0.932) with significant path coefficients ($p < 0.10$). The R^2 values also improved (0.565 versus 0.606). Therefore even though the original proposed model of user success in a digital library environment did not fully explain user success, the modified version of the proposed model did much better in terms of both model fit and path coefficients between latent variables. The resulting modified model includes three of the original independent latent constructs (Content, Timeliness and Service Quality) and the three dependent latent variables (Use, User Satisfaction and User Success). Among the three independent latent variables dropped from the originally proposed model, System Quality, is perhaps a stronger candidate to be added to a future model. It is not justified to drop System Quality based on results from a prototype digital library. Therefore based on the results of this study (even though I didn't find support for the original

proposed model) the modified version of the comprehensive plus model (Figure 13) of user successes in a digital library environment (with System Quality as an additional independent latent variable) is proposed as a viable alternative.

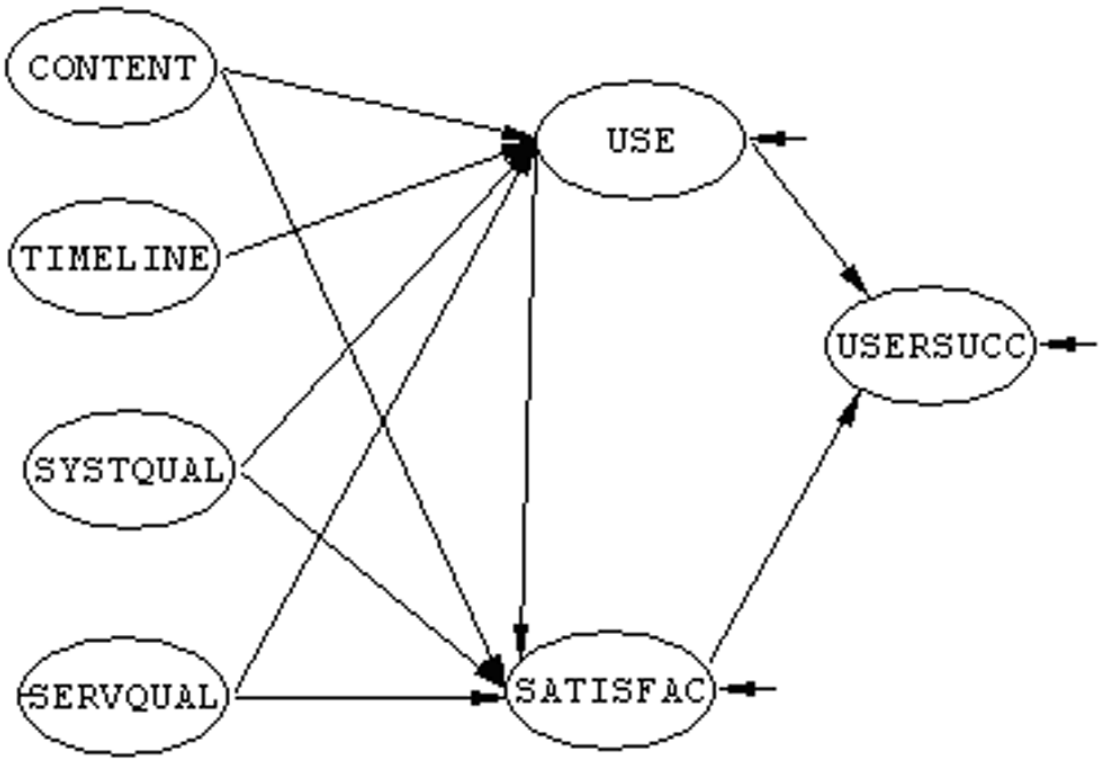


Figure 13. The modified comprehensive plus model of user success in a digital library environment.

Limitations of the Study

In addition to those stated in Chapter 1, the study may have a number of limitations. Some of these are due to their nature of being difficult to control. Therefore results must be treated with caution. Generally the following could have contributed to results and findings of the study:

- Negatively worded items in the questionnaire. These items did not load very well on their respective scales at the time of factor analysis and most of them contributed to low internal consistency (reliability) of the scales.

- Sample size and response rate. Even though a sample size of 160 is adequate for an exploratory study, this can not be ruled out as a possible limitation. For instance, the type of estimation method used (i.e., maximum likelihood) in LISREL is based on the assumption that the sample size is large enough (usually > 200). Low response rates are often cited as possible limitations.
- The sample. The convenience sample could be a limitation of the study with respect to the generalizability of the study's results.
- Self report. Any study based on self reported variables and information should also consider as a limitation.
- The prototype digital library. The fact that the prototype digital library used in the study is not a fully fledged and widely used tool may have had some effect especially on the measurement of some of the independent latent variables.

In spite of these limitations, the study reported in this dissertation makes a number of important contributions to the literature. While it builds on past research and theories, it could also be used as a foundation for future research.

Concluding Remarks

This dissertation study is based on a number of previous theoretical models specified and sought to determine the extent to which two competing models of user success in a digital library environment. To achieve this, an online survey questionnaire was designed with items measuring nine latent variables. Data collected from 160 users of a prototype digital library was subjected to a number of analyses such as exploratory factor analysis, confirmatory factor analysis, and structural equation modeling. Data screening showed that items in the instrument satisfy the normality criteria and the various scales and the pilot-tested instrument have good validity and reliability. Exploratory and confirmatory factor analyses produced a factor structure with nine distinct factors corresponding to the nine latent variables in the two models.

Structural equation modeling using LISREL produced mixed results. While the two models (RQ1 & RQ2) fit the sample data well, relationships among some of the latent variables were not significant. Whenever possible, the original model was modified in order to find a combination of latent variables that not only fit the sample data but also have significant relationships hypothesized in the original theory. A modified version of the proposed comprehensive plus model of user success in a digital library environment both fit the sample data and at the same time the latent variables significant relationships as evidenced by significant path coefficients ($p < 0.10$). Even though the research failed to support both original models (RQ1 & RQ2) based on the sample data, a modified version of the proposed model performed much better in terms of both model fit and significant relationships between latent variables. The resulting modified model includes three of the original independent latent constructs (Content, Timeliness and Service Quality) and the three dependent latent variables (Use, User Satisfaction and User Success). Among the three independent latent variables dropped from the originally proposed model, System Quality is perhaps a stronger candidate to be added to a future model. Therefore, the modified version of the comprehensive plus model of user successes in a digital library environment (Figures 12 & 13) is proposed as a viable alternative. The modified model does not stipulate any new relationships between the latent variables other than those already confirmed by previous theory and research.

Implications of Research Findings

This study's contribution to the general topic of user success in a digital library

environment lies in the fact that two competing models fit the sample data even though it failed to support some of the relationships between the latent variables in the models. It could be said that the study also found support for the constructs in those models. It has also shown that most of the items usually used to measure the latent variables are both valid and reliable, adding to the external validity and reliability of instruments used for measuring factors that affect user success in a digital library environment. Therefore future similar research could justify use of the instrument on the basis that it has already shown to produce data that the various relevant models fit.

Recommendations for Future Research

This study is just another one in the continued effort by researchers to understand the nature of user success in digital libraries in general. It is by no means a conclusive study. Because, the modified version of the proposed model of user success in a digital library environment is as a result of careful analyses of data from a single sample of users of a prototype digital library users. In addition to that, results of the study do not suggest any departure from those of previous research and theory. What it does though is raise a question as to what combinations of the possible factors affect user success in a digital library environment, thereby pointing to a need for further research to modify and refine previous relevant models and theories and continue the search for a parsimonious model.

There are a number of areas that require further research to look at. Chief among these is the effect of negatively worded items in the instrument on its validity and reliability. This could only be the case for the current study because I did not find similar

comments by other researchers. A number of limitations of the current study also calls for and justifies further research on the topic. The effect of the type of the digital library (whether it is a prototype or a fully fledged system) and the experience of users in using it should also be looked into. In order to pinpoint possible reasons for low correlations between some of the independent latent variables and the dependent latent variables data obtained using the online instrument could be supplemented by data obtained through interviews conducted to solicit these reasons from users of the digital library.

Summary

This chapter presented a short summary of findings of the current study. The two research questions that guided the study were re-iterated with relevant results from a number of statistical analyses including exploratory and confirmatory factor analyses as well as structural equation modeling. Results from the analyses on one hand support the two competing models of user success in a digital library environment while on the other failed to support some of the relationships between the latent variables as hypothesized by the two models. However a modified version of the comprehensive plus model originally proposed was specified and recommendations were made for future researchers to look into the possible combinations of factors that affect user success in a digital library and re-specify the existing models.

Limitations of the study were identified and clearly stated in order for readers to have a context within which to interpret the results and make sense of the conclusions. The chapter also includes implications of research findings and recommendations for future research. No research report can claim to have covered the whole width and

breadth of a topic as broad as user success in a digital library environment. This dissertation is no different. Therefore the recommendations were made for future research with this in mind.

APPENDIX A

CONSENT FORM AND COVER LETTER

Dear UTD student,

I hope everything is going well and you are enjoying your classes. Thank you very much for volunteering to participate in my dissertation research. Your participation in this survey is entirely voluntary.

I understand that you are already an UTD digital library system user. The system is available at http://encompass.utdallas.edu. You can also find the link under “Test the Federated Search” from UTD library Catalog available at http://library.utdallas.edu. If you need more time to familiarize yourself with the functionalities and services provided by the UTD digital library system please do so.

The survey is available at http://www.faizur.org/final_version/survey_page1.htm. You will also find a link to the survey at the bottom of the UTD digital library page. The survey will take you approximately 20 minutes. Find a convenient time and place to complete the survey. Please do not start if you can not complete it and complete it once you start it. Please do not quit until you are told that you have completed the survey. If your responses reflect a good effort to review the UTD digital library and you have respond to all the questions in the survey, your efforts were rewarded with a gift certificate redeemable at a major food chain store. Please don’t forget to take a note of your unique submission ID displayed at the last page of this survey.

Once again, the UTD digital library system is available at:

http://encompass.utdallas.edu.

When you are ready, please click on the URL (Web address) for my survey page below:

http://www.faizur.org/final_version/survey_page1.htm.

Thank you very much for your time.

Faizur Rahman
Doctoral Student
Department of Information Science
University of North Texas
Denton, TX 76203

APPENDIX B

SURVEY QUESTIONNAIRE

UNIVERSITY OF NORTH TEXAS

School of Library and Information Sciences (SLIS)

An Empirical Investigation of Factors that Influence User Success in a Digital Library Environment

Faizur Rahman

Thank you for taking your time to participate in our study. This survey is being conducted by Faizur Rahman, Doctoral Student at the University of North Texas School of Library and Information Sciences. The purpose of this study is to test a user success model in a digital library environment. This survey will take approximately 15 minutes to complete. Participation is voluntary. If you give permission by completion of the survey, no individual responses were reported to anyone. If you have any questions regarding this study, please contact Mr. Faizur Rahman at (972) 883-4100 or Dr. Guillermo Oyarce, UNT School of Library and Information Sciences, (940) 565-3568. This project has been reviewed and approved by the UNT Institutional Review Board (940) 565-3940. Please complete the questionnaire in its entirety.

Instructions:
Please try to respond to all items.
For each questions only one response is expected.
To mail in your results, click on: Submit.

(1= never; 2= seldom; 3= sometimes; 4= usually;5=always)

	1	2	3	4	5
1. The digital library provided the exact information necessary.	☐	☐	☐	☐	☐
2. The information itself satisfied my needs.	☐	☐	☐	☐	☐
3. The search result was almost exactly the thing I needed.	☐	☐	☐	☐	☐
4. The digital library provided plenty of information.	☐	☐	☐	☐	☐
5. The information was produced in a timely manner.	☐	☐	☐	☐	☐
6. The digital library provided up-to-date information.	☐	☐	☐	☐	☐

NEXT >

(1= never; 2= seldom; 3= sometimes; 4= usually; 5= always)

	1	2	3	4	5
7. The digital library was easily adaptable to me.	☐	☐	☐	☐	☐
8. The digital library was always available to me.	☐	☐	☐	☐	☐
9. The digital library was reliable to me.	☐	☐	☐	☐	☐
10. I was satisfied with the digital library response time.	☐	☐	☐	☐	☐
11. The digital library was useable to me.	☐	☐	☐	☐	☐
12. Using the digital library bored me.	☐	☐	☐	☐	☐
13. The digital library is inherently interesting.	☐	☐	☐	☐	☐
14. It was very enjoyable to use the digital library.	☐	☐	☐	☐	☐

Next >

(1= never; 2= seldom; 3= sometimes; 4= usually; 5= always)

	1	2	3	4	5
15. I was confident in using the digital library.	☐	☐	☐	☐	☐
16. I could not control the activities involved in accessing the digital library.	☐	☐	☐	☐	☐
17. When using the digital library, I was able to control all aspects of my access to the computer.	☐	☐	☐	☐	☐
18. I was satisfied with the easy way to use the digital library.	☐	☐	☐	☐	☐
19. I have empathy (not enjoyable and comfortable) to use the digital library.	☐	☐	☐	☐	☐
20. I was satisfied of the responsiveness of digital library support.	☐	☐	☐	☐	☐

(1= never; 2= seldom; 3= sometimes; 4= usually; 5= always)

	1	2	3	4	5
21. I use digital library for my class work.	☐	☐	☐	☐	☐
22. I navigate the digital library to find information.	☐	☐	☐	☐	☐
23. I visit different sites to find information within digital library.	☐	☐	☐	☐	☐
24. I download information from digital library in every visit.	☐	☐	☐	☐	☐
25. I intend to use the digital library services in the future.	☐	☐	☐	☐	☐
26. I intend to visit the digital library in the future.	☐	☐	☐	☐	☐
27. I intend to participate in the digital library User surveys in the future.	☐	☐	☐	☐	☐

Next >

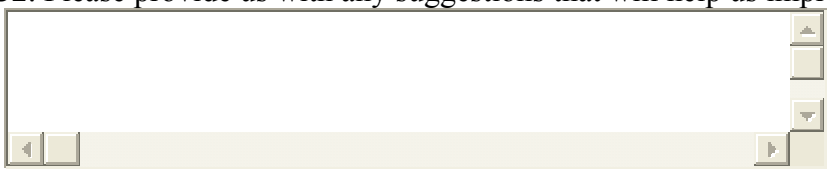
(1= never; 2= seldom; 3= sometimes; 4= usually; 5= always)

	1	2	3	4	5
28. I feel the digital library is able to meet my information needs in my area of interest.	☐	☐	☐	☐	☐
29. I feel the digital library is able to meet the requirements of all users it serves.	☐	☐	☐	☐	☐
30. I feel the digital library is efficient.	☐	☐	☐	☐	☐
31. I feel the digital library is effective.	☐	☐	☐	☐	☐

Next

---

32. Please provide us with any suggestions that will help us improve the digital library design and services:



33. Your current occupation

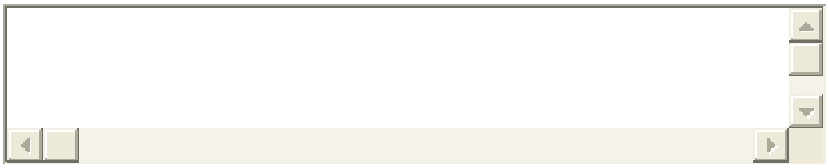
☐ Undergraduate student ☐ Master's student ☐ Doctoral student Other: ☐

34. Highest degree earned:

☐ High School ☐ Associate ☐ Bachelor's ☐ Master's ☐ Doctoral Other: ☐

35. Gender: ☐ Male ☐ Female

36. Comments:



Submit

Thank you for participating! Your input is greatly appreciated. If you have questions or comments, please email Faizur Rahman sfr0003@unt.edu.

APPENDIX C

IRB APPROVAL LETTER

UNIVERSITY of NORTH TEXAS

Office of Research Services

July 25, 2005

Faizur Rahman
School of Library and Information Sciences
University of North Texas

RE: Human Subjects Application No. 05-208

Dear Mr. Rahman:

Your proposal titled "An Empirical Investigation of Factors that Influence User Success in a Digital Library Environment" has been approved by the Institutional Review Board and is exempt from further review under 45 CFR 46.101. **Federal policy 45 CFR 46.109(e) stipulates that IRB approval is for one year only.**

It is your responsibility according to U.S. Department of Health and Human Services regulations to submit annual and terminal progress reports to the IRB for this project. Please mark your calendar accordingly. The IRB must also review this project prior to any modifications.

Please contact Shelia Bourns, Compliance Administrator, ext. 3940 or Boyd Herndon, Director of Research Compliance, ext. 3941, if you wish to make such changes or need additional information.

Sincerely,

Scott Simpkins, Ph.D.
Chair
Institutional Review Board

SS:sb

P.O. Box 305250 ◆ Denton, Texas 76203-5250 ◆ (940) 565-3940
Fax (940) 565-4277 ◆ TTY (800) RELAY TX ◆ www.unt.edu

REFERENCES

Arms, William. (2003). *Digital libraries.* Cambridge, MA: MIT Press. Retrieved October 25, 2007, from: http://www.cs.cornell.edu/wya/DigLib/MS1999/index.html

Association of Research Libraries. (n.d.). *Definition and purposes of a digital library*. Retrieved October 25, 2007, from: http://www.arl.org/resources/pubs/mmproceedings/126mmappen2

Baroudi, J. and Orlikowski, W. J. (1988). A short-form measure of user information satisfaction: A psychometric evaluation of notes on use. *Journal of Management Information Systems, 49*(4), 44-59.

Belkin, N., & Croft, B. (1992). Information filtering and information retrieval: Two sides of same coin? *Communications of the ACM, 35*(12), 29-38.

Bentler, P. M. (1990). Comparative fit indices in structural models. *Psychological Bulletin, 107*, 238-246.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*, 588-606.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York, NY: Wiley.

Bollen, K. A., & Long, J. S. (1993). Introduction. In K.A. Bollen, & J.S. Long (Eds.), *Testing structural equation models*. Beverly Hills, CA: Sage.

Borgman, C. L. (2000). *From Gutenberg to the global information infrastructure: Access to information in the networked world*. Cambridge, MA: MIT Press.

Chang, S and Rice, R (1993). Browsing: A multidimensional framework. *Annual Review of Information Science and Technology, 28*, 231-276.

Cheng, C. K., and Pan, X. (2003). Using perception in managing unstructured documents: Crossroads. *Cognitive Science, 10*(2), 18-23.

Cooper, M. D. (2001). Usage patterns of a Web-based library catalog. *Journal of the American Society for Information Science, 52*(2), 137-148.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297-334.

Csikszentmihalyi, M. (1977). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass.

DeLone, W. H. & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, *3*(1), 60-95.

DeLone, W. H. & McLean, E. R. (2002). Information systems success revisited. In *Proceedings of the 35th Hawaii International Conference on System Sciences.* Hawaii: IEEE, The Computer Society.

Delone, W. H. & McLean, E. R. (2003).The DeLone & McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9-30.

DeVellis, R. F. (1991). *Scale development: Theory and applications*. Newbury Park, CA: Sage

Digital Library Federation (n.d.). Available at: http://www.clir.org/pubs/annual/annrpt97/libraries.html

Doll, W. and Torkzadeh, G. (1988). The measurement of end user computing satisfaction: Theoretical and methodological issues. *MIS Quarterly*, *12*(2), 259-274.

Fox, E. A., Hix, D., Nowell, L.T (2000). Digital libraries: Situating use in changing information infrastructure. *Journal of the American Society for Information Science, 51*(40), 394-413.

Garrity, E. J. & Sanders, G. L. (1998) *Information Systems Success Measurement*. Hershey, USA: Idea Group Publishing.

Gatian, A. (1994). Is user satisfaction a valid measure of system effectiveness? *Information & Management, 26*, 119-131.

Ghani, J. A. (1995). Flow in human-computer interactions: test of a model. In J. M. Carey (Ed.), *Human factors in information systems: Emerging theoretical bases*. Norwood, NJ: Ablex Publishing Corp., 291-311.

Griffiths, J. R., Hartley, R. J., & Willson, J. P. (2002). An improved method of studying user-system interaction by combining transaction log analysis and protocol analysis. *Information Research*, *7*(4). Retrieved March 20, 2003, from http://InformationR.net/ir/7-4/paper139.html

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis with readings* (5th ed.). Englewood Cliffs, NJ: Prentice Hall.

Hoffman, D.L. and T.P. Novak. (1996). Marketing in hypermedia computer- mediated environments: Conceptual foundations. *Journal of Marketing, 60*, 50-68.

Huang, C., K., Chien, L., F., & Oyang, Y., J. (2003). Relevant term suggestion in interactive Web search based on contextual information in query session logs. *Journal of the American Society for Information Science, 54*(7), 638–649.

Ives, B., Olson H., & Baroudi, J. (1983). The measurement of user information satisfaction. *Communications of the ACM*, *26*(10), 785-793.

Jöreskog, K. G. (1993). Testing structural equation models. In K.A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 294-316). Newbury Park, CA: Sage Publications.

Jöreskog, K., & Sörbom, D. (1993). *LISREL 8: Structural equation modeling with the SIMPLIS command language*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Joshi, K. (1990). An investigation of equity as a determinant of user information satisfaction. *Decision Sciences*, *21*(4), 786-807.

Jung, J. T. (1997). Measuring user success in the digital library environment, *Dissertation Abstracts International*, (UMI No. DAI –A 58/06), Retrieved November 22, 2004, from Digital Dissertations database.

Kantor, P. B. (1994). Information retrieval techniques. *Annual Review of Information Science and Technology, 29*, 53-90.

Kelloway, E. K. (1998). *Using LISREL for structure equation modeling: A researcher's guide*. Thousand Oaks: Sage.

Kettinger, W. (1994). Perceived service quality and user satisfaction with the information services function. *Decision Sciences, 25*(5-6), 737-766.

Marchionini, G., Plaisant, C., & Shneiderman, B. (2000a). Previews and overviews in digital libraries: Designing surrogates to support visual information seeking. *Journal of the American Society for Information Science, 51*(4), 380-393.

Marchionini, G., Plaisant, C., & Shneiderman, B. (2000b). Children's use of the Yahooligans! Web search engine: I. Cognitive, physical, and affective behaviors on fact-based search tasks. *Journal of the American Society for Information Science,* 51(7), 646-665.

Molla, A. & Licker, P. (2001). E-commerce systems success: An attempt to partially extend and respecify the DeLone & McLean model of IS success. *Journal of Electronic Commerce Research, 2*(4), 131-141.

Netemeyer, R. G., Bearden, W. O., & Sharma, S. (2003). *Scaling procedures: Issues and applications*. Thousand Oaks, CA: Sage Publications.

Noerr, P. (2003). The digital library toolkit. Available at: http://www.sun.com/products-n-solutions/edu/whitepapers/digitaltoolkit.html

Nunnally, J.C., & Bernstein, I. H. (1994). *Psychometric theory*. New York: McGraw-Hill.

Plaisant, C., Shneiderman, B., Doan, K., & Bruns, T. (1999). Interface and data architecture for query preview in networked information systems. *ACM Transactions on Information Systems, 17*(3), 320-341.

Rubin, A., and Babbie, E. (1997). *Research methods for social work* (3rd ed.). Pacific Grove, CA: Brooks/Cole Publishing Company.

Ruthven, I., Lalmas, M., & Rijsbergen, K., V. (2003). Incorporating user search behavior into relevance feedback. *Journal of the American Society for Information Science, 54*(6), 529–549.

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana, IL: University of Illinois Press.

Schumacker R., & Lomax (2004). *A beginner's guide for structural equation modeling* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Shneiderman, B. (1998). *Designing the user interface: Strategies for effective human-computer interaction*. Boston: Addison-Wesley.

Spector, P.E. (1992). *Summated rating scale construction: An introduction*. Newbury Park, CA.: SAGE Publications.

Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research, 25*, 173-180.

Stettheimer, T. D. (2000). *Modeling utilization of planned information technology*. Unpublished Doctoral Dissertation. Retrieved December 20, 2004, from ISDoc Digital Dissertations database.

Tabachnick, B. G. & Fidell, L. S. (1989). *Using multivariate statistics* (2nd ed.). New York: HarperCollins.

Tanaka, J. S. (1993). Multifaceted conceptions of fit in structural equation models. In K. A. Bollen & J. S. Long (Eds.), *Testing Structural Equation Models*. Newbury Park, CA: Sage.

Trevino, L.K & Webster, J. (1992). Flow in computer-mediated communication. *Communication Research, 19*(5), 539-573.

Wang, P., Berry, M. W., & Yang, Y. (2003). Mining longitudinal Web queries: Trends and patterns. *Journal of the American Society for Information Science, 54*(8), 743–758.