A DIGITAL LIBRARY SUCCESS MODEL FOR COMPUTER SCIENCE STUDENT USE OF A META-SEARCH SYSTEM

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ABSTRACT

The success of any product of Information Technology lies in its acceptance by the target audience. Several behavioral models have been formulated to analyze factors that affect human decisions to accept new technology while some technology is already in place. These models enable us to identify the areas of concern within the system and its environment and to address them. However, these models are based in industrial settings, and are more suited to situations when a person is introduced to the field of Information Technology. A separate stream of research tries to model the factors that cause an Information System, especially at the workplace, to be termed a success. No such models exist for the academic community and the Computer Science student community, in particular. In this thesis, the success of a new academic meta-search system for the Computer Science student community is measured and the extent to which various factors affect this success is identified. For this purpose, an Information System success model is composed with the help of models for technology acceptance and Digital Library quality metrics. The resultant model is then used to formulate a survey instrument and the results of a user study with this instrument are used to begin to validate this model.

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This being my first stint with research, I needed constant prodding and direction. Dr. Fox has been patient with me and helped me with all issues that came up during the course of my thesis. Dr. Fan and Hui Lin guided me during the statistical analysis of the model. My heartfelt thanks go to them.

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Given the nature of the thesis, I had to have many users take up a study. Help flowed in from many quarters, from known and unknown faces. I should thank them all. Also, special thanks go to both Pengbo and Srinivas who helped me with equipment when my computer crashed.

During my life of being a graduate student, I gained particular inspiration from taking courses under Dr. Godmar Back, Dr. Eunice Santos, and Dr. Robert Broadwater. I can now confidently call myself an engineer, thanks to them.

CHAPTER 1: PROBLEM DESCRIPTION AND APPROACH

Various search engines are currently available to the academic community. When a new search engine is introduced to the community, various factors contribute to its acceptance. These factors and the extent to which each factor affects the overall acceptance of the new search engine need to be identified. The relationship between each of these factors needs to be established. A model of the process of reaching at the decision, regarding if a new search engine should be used instead of others, also needs to be scientifically verified for correctness.

The Computer Science academic community uses various commercial search engines such as Google™, Yahoo!™, etc., as well as academic search engines such as CiteSeer, IEEE, etc. As a part of a research project funded by the Institute of Library and Museum Sciences (IMLS) [Grant #415019], Emory University is constructing a meta-search engine to better address the needs of the Computer Science academic community. Given that the community is already accustomed to some tools of realizing their goals, the acceptance of this new search engine, and the factors which affected users' preferences were studied.

This could have been done by asking the target audience to use the search engines for a while, and then asking them if they were satisfied with it or not. However, in the case of a user being unsatisfied, specific feedback about what was negatively affecting the user, and to what extent it was affecting them, would probably not be obtained.

When a model of system acceptance is formulated, the possible visible and invisible factors that could affect the user's satisfaction, and subsequently the acceptance of the system, are brought together, and the cause and effect relationships among these factors are identified. The target community also could have some unique characteristics which might be useful to be discovered so that future efforts can be directed by exploiting that knowledge. Some perceived factors might not have any influence at all, and so such knowledge gained could save a considerable amount of effort. Also, useful knowledge can be gained which can be used proactively regarding other products/systems designed for the same community in future.

The extent to which each factor has a bearing on the overall acceptance needs to be scientifically proved. Based on the facts that there exist multiple variables that determine acceptance and that these variables might interact, the model derived should be a multiple linear regression model. Multiple linear regression analysis establishes the coefficients for such variables, in effect showing the extent to which they affect a variable of interest. Having established the extent to which one factor affects another, corrective measures regarding negative effects can be prioritized. In general, such corrective or other measures might have a cascading effect on those factors on which they have a direct or indirect causal effect. These various considerations have led researchers to build models and apply suitable regression analyses for measuring acceptance and satisfaction.

The next section describes the meta-search system that was developed, and which we were charged to help evaluate. The subsequent section summarizes the various models that were studied to derive a model that would represent assist with our assessment work. The synthesis of this model is explained in detail in the following section.

CHAPTER 2: THE META-SEARCH SYSTEM

This chapter provides an overview of the system that was tested for acceptance. The features offered by the meta-search engine are explained and visual examples are provided.

Search engines are used primarily for one of two reasons:

- *Locating* an artifact whose identity is already known

- *Exploring* for an artifact. This often is based on some pre-formulated idea.

The meta-search engine was developed by researchers at Emory University in an attempt to better address the needs of the academic community. The system was built using an iterative approach – a prototype is constructed, focus groups comment on these prototypes, these comments are taken into account, another prototype is constructed, and the cycle repeats again.

The user's goal while using the search engine cannot be known beforehand. To overcome this problem, this meta-search engine provides four different views for the same results, and the user is allowed to choose the view that suits best.

The meta-search engine was designed to work with Firefox™. Access to this search engine was set up on a web server. The data for the search-engine index was obtained from the collections available at CITIDEL (Computing and Information Technology Interactive Digital Educational Library), located at http://www.citidel.org, which houses meta-data harvested from various sources.

The CIC (Committee on Institutional Cooperation) view arranges the results in the order of decreasing text similarity. It was named because of the similarity to how the CIC portal lays out results. A snapshot of the CIC view is shown in Figure 1.

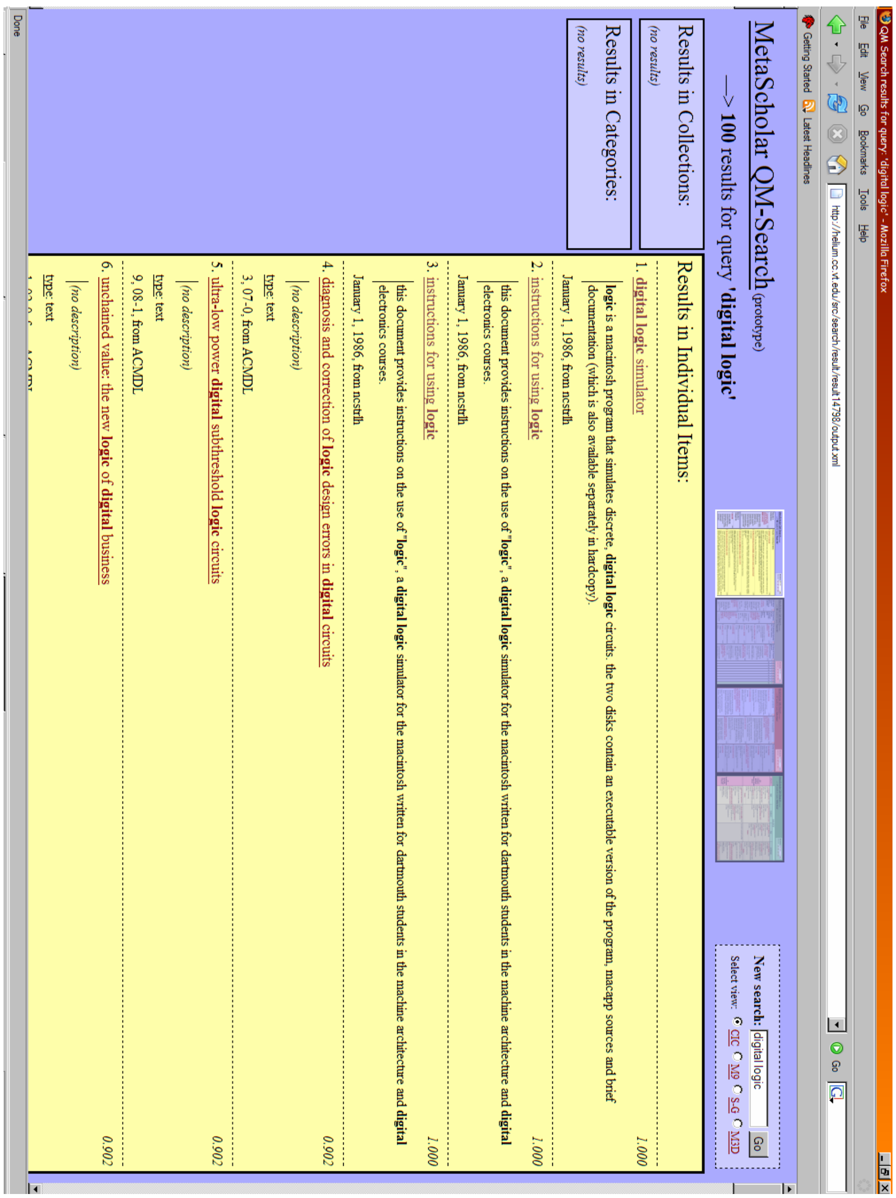

Figure 1: CIC Portal View

The Meta-9 (M9) view was so named because of its similarity to the commercial A9™ search engine. It divides the results into bins based on the collections from where the resources are obtained. The user can collapse/expand each collection bin. The individual results within each bin are ordered based on text similarity. This provides two dimensions to the ordering. An illustration of the M9 view is given in Figure 2.

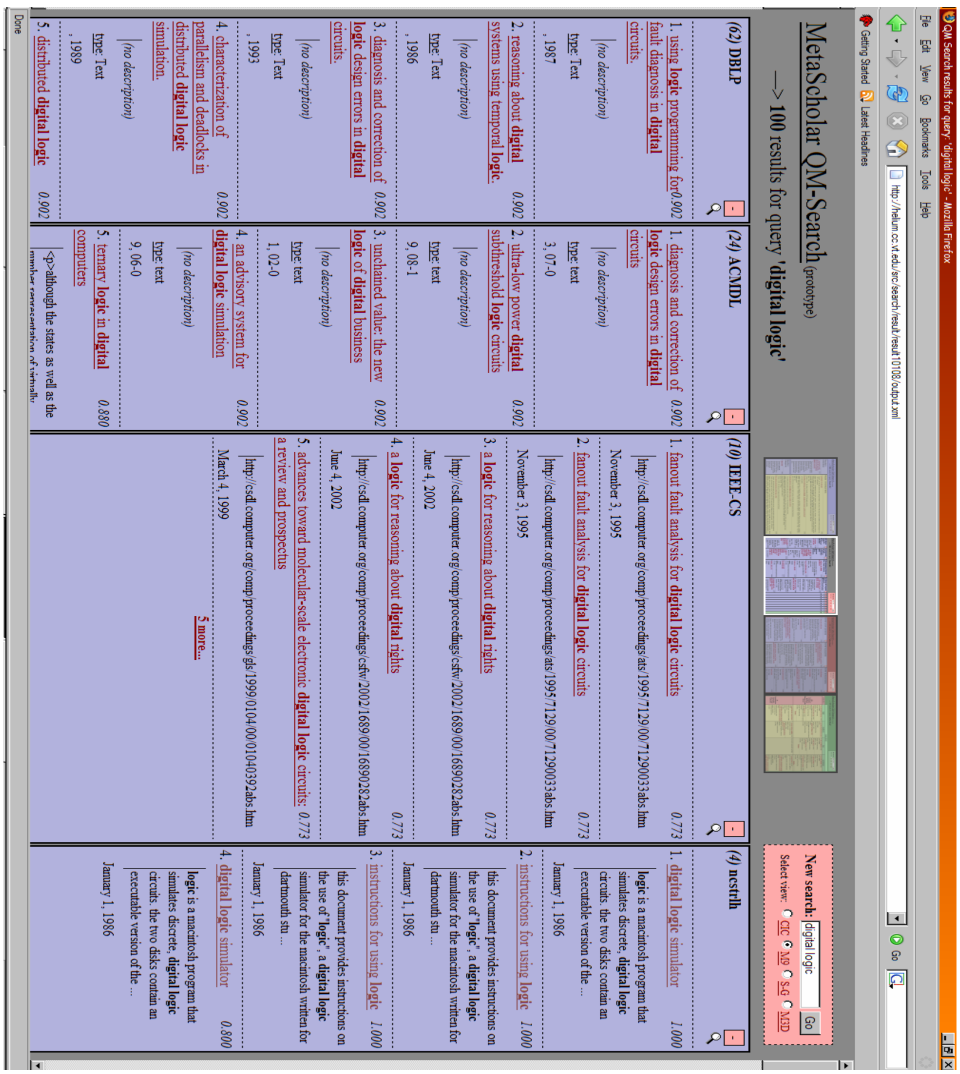

Figure 2: M9 View

The S-G (Super-Google) view arranges the results after ordering them based on popularity, text similarity, and both metrics and laying them next to each other. Popularity could have different definitions – number of clicks leading to a resource, the number of times it is rated highly by researchers, etc. In this case, the rating provided by other academicians was taken to be the definition of popularity. A snapshot of the S-G view is shown in Figure 3.

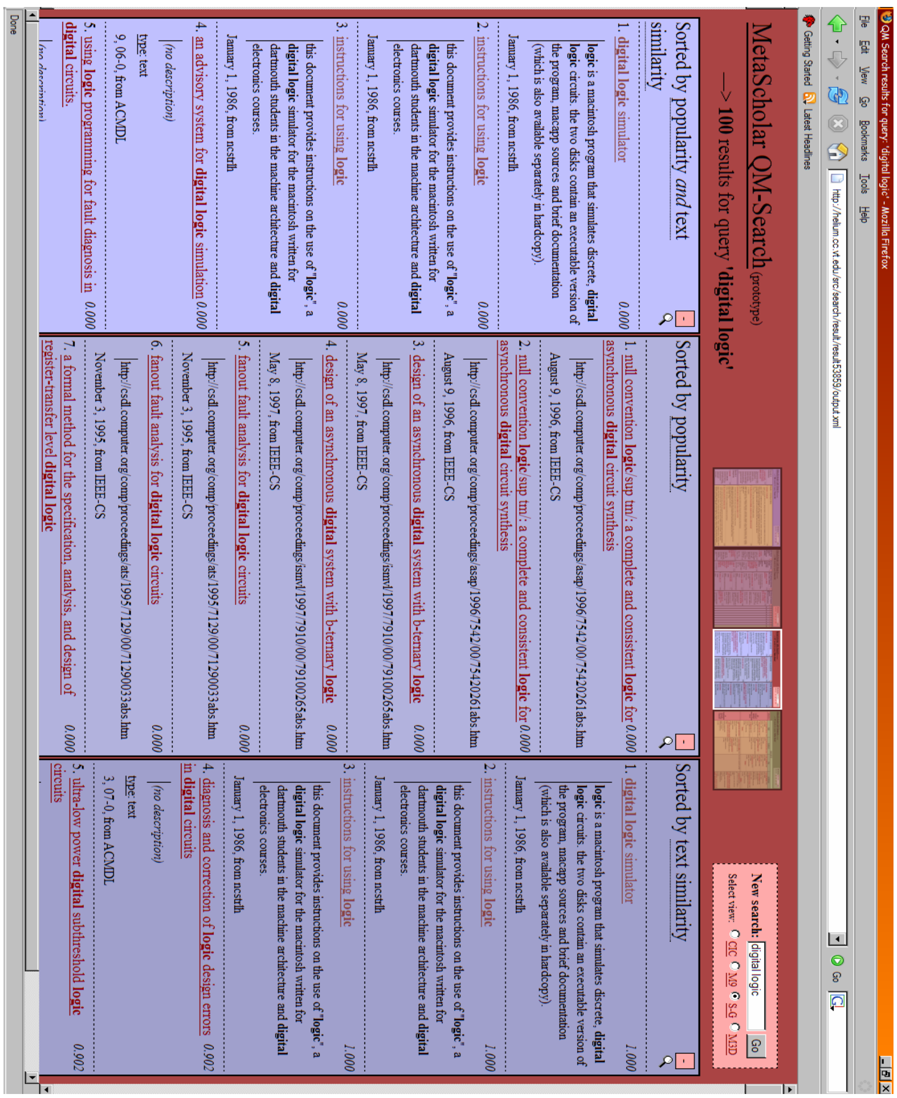

Figure 3: Super-Google View

The Meta-Scholar 3-D view goes one step further and arranges results in a three-dimensional manner. The results are primarily divided by the collections from where they are obtained. These results are then segmented in accordance with the popularity of the resources into four categories, namely highest, high, medium, and low/unknown. Within each of these categories, the results are arranged in decreasing order of text similarity to the query. A snapshot is shown below in Figure 4.

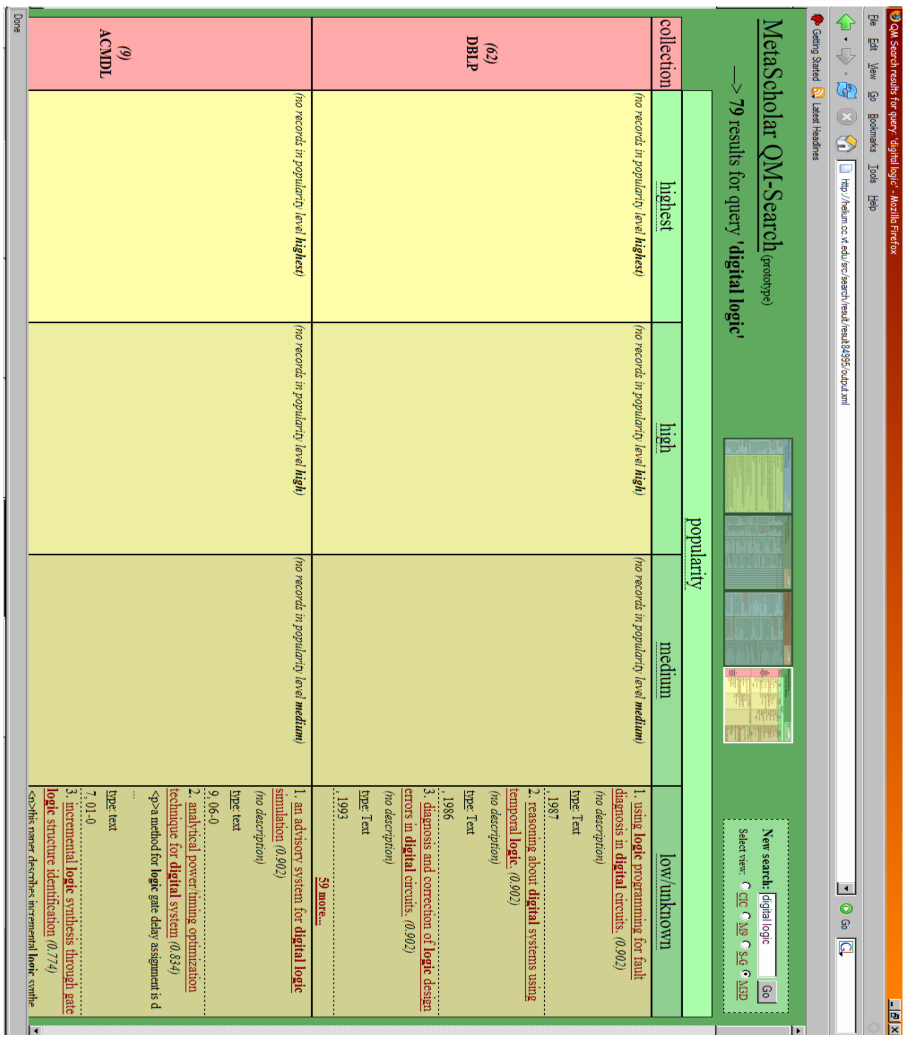

Figure 4: Meta Scholar 3D View

CHAPTER 3: LITERATURE REVIEW

This section summarizes knowledge gained from existing models from a historical and a learning perspective. Knowledge gained from these models was used in formulating an acceptance model specifically for the Computer Science student community, but possibly also for others in the academic world.

The literature reviewed for this thesis can be broadly classified into three categories – technology acceptance, Information Systems (IS) success, and Digital Library (DL) quality metrics.

Considerable interest was expressed in studying technology acceptance since the '80s when Information Technology was clearly seen to have an impact on people's lives. In those days, computers were being introduced at the workplace. However, many of the anticipated benefits did not accrue, due to reluctance of users to accept computers and the associated software systems. This caused researchers, particularly in the Behavioral Sciences community, to explore what the reasons might be. While some researchers treated this as a new problem and started developing customized models, others looked at this as a special case of the Theory of Reasoned Action [7] (summarized in Figure 5) and looked at it from the perspective of human behavior in the wake of a new device being introduced in their way of life. The Theory of Reasoned Action explains actual human behavior to be the outcome of the effect of two categories of significant beliefs – behavioral and normative.

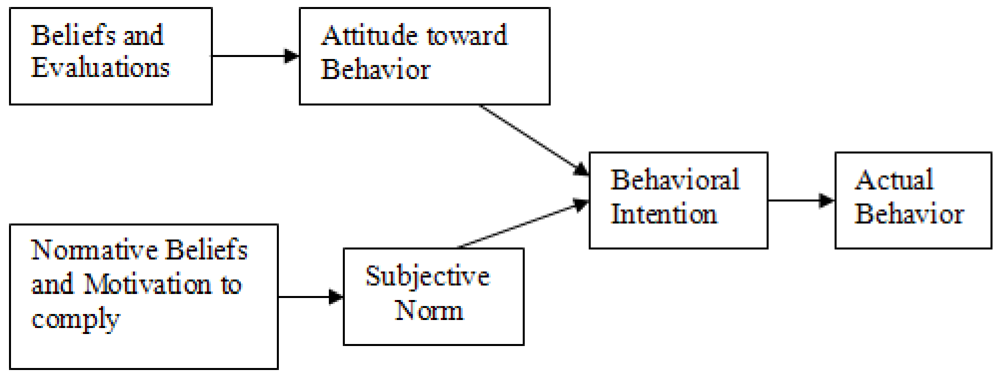

Figure 5: Theory of Reasoned Action

Behavioral Beliefs can be mathematically explained as the sum of products of various aspects of behavioral belief and the user's evaluation of their importance ($\Sigma\ b_i e_i$). Normative Beliefs is similarly the sum of products of various aspects of belief about social compliance and the user's evaluation of their importance ($\Sigma\ nb_i mc_i$). While the behavioral beliefs reflect one's attitude towards behavior, normative beliefs act as indicators of social pressure.

One of the earliest studies was reported by Bailey et al. [3] in which they attempted to develop a tool that would measure and analyze computer user satisfaction. It is a simple one-level model that attempts to list the factors that might affect user satisfaction and identifies the perceived importance of each of them to the user.

Mathematically, user satisfaction can be expressed as

$$S_i = \Sigma\ R_{ij} W_{ij} \text{ with } j \text{ varying between 1 and } n$$

where R_{ij} = the reaction to factor j by individual i and W_{ij} = the importance of factor j to individual i.

One interesting aspect is that it takes care of the fact that the importance of each factor might be different for different users. However, it does not take care of the relationship between these factors. Moreover, it is tailor-made for a user who is made to get accustomed to a computer in the workplace. This becomes evident from the work reported by Doll et al. [11]; they could not reuse this model but instead had to develop a model from scratch so as to measure end-user computing satisfaction for users who had to deal with database management systems. Also, this study was conducted in a time period when users were getting accustomed to computers in the workplace. It does not suit today's situation where computers are ubiquitous, nor in the scope of this thesis where the need is to measure the satisfaction of the academic user of using a meta-search system; that requires a fresh approach.

Davis et al. [7] studied two different models – the Theory of Reasoned Action (TRA) and the Technology Acceptance Model (TAM) - to see how they performed with respect to a specialized user class; computer users. Studies in the field of behavioral sciences led to the development of TRA by Fishbein and Azjen [12]. That model is highlighted in Figure 5; it was successful in predicting and explaining behavior across a wide variety of domains. However, as the authors of [8] observed, TRA was too general, and so led to the development of the Technology Acceptance Model (TAM) [8], that explains computer usage behavior specifically. It is illustrated in Figure 6, for a quick reference. TAM builds on a wealth of knowledge of Information Systems (IS) accumulated over a decade, and is well-suited to model computer acceptance. External variables are introduced. The notion of there being no relationship between Perceived Usefulness (U) and Perceived Ease of Use (E) was done away with. Also, the significant effect of Perceived Usefulness on the intention to use was brought out by introducing a causal relationship between them.

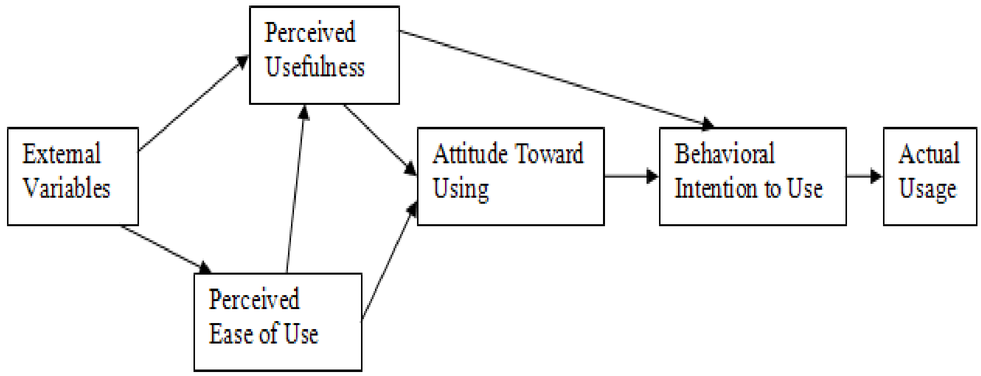

Figure 6: Technology Acceptance Model

Both models were tested with a set of users who were introduced to a new word processor. Attitudes intervened between beliefs and intentions lesser than was predicted by TRA and TAM. They recommended further research to identify the conditions under which attitudes mediate the belief-intention link.

In another study, Davis [9] observed that valid measurement scales for predicting user acceptance were in short supply and tried establishing such scales for Perceived Ease of Use (E) and Perceived Usefulness (U) in the TAM. The set of scale items that were suggested initially were subjected to a pilot test and analysis for reliability and validity. The set was refined to ten each for usefulness and ease of use. Two studies were conducted to see how well the scale could be adapted across systems. In keeping with the observation of Cohen et al. [4], in both studies, usefulness was more strongly linked to usage than ease of use. It also was pointed out that the effect of intrinsic motivation as a factor needs to be studied. This was a pointer for research in the future.

Alternative theories were explored to explain the behavior of people with computers. One such theory was proposed by Triandis[24]. Thompson et al. [23]

used this theory to identify factors affecting user acceptance. They found that social norms and three components of expected consequences, namely complexity of use, fit between the job and PC capabilities, and long-term consequences play important roles. However, the theory does not signify the relation between effect and utilization as discovered by the authors. In other words, the results suggest the importance of training in the deployment process.

Meanwhile, the TRA, on which the TAM was built, was subjected to an overhaul. Ajzen [2] did a detailed analysis and came up with the Theory of Planned Behavior (TPB) to "overcome the limitations that deal with behaviors over which people have incomplete volitional control". He added Perceived Behavioral Control as another factor that affects behavioral intention, and that affects behavior (mildly) as well. Interdependencies between attitude and subjective norm, subjective norm and perceived behavioral control, and attitude and behavioral control, were added to make the model more complete.

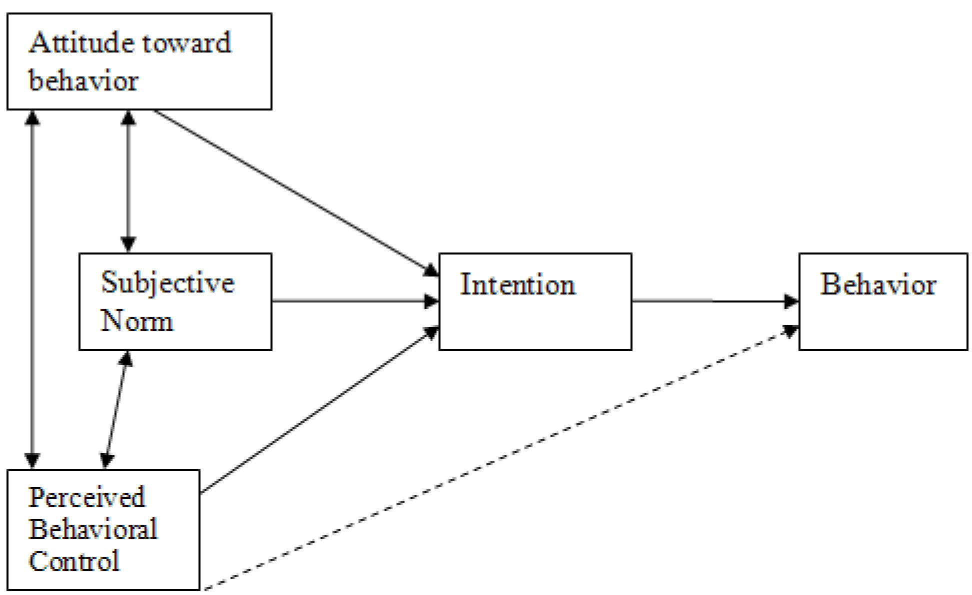

Figure 7: Theory of Planned Behavior

The model was empirically studied, and the authors claim to have proved the sufficiency of the theory.

While the above literature attempted to model the Information System in the context of an environment of the user, Compeau et al. [5] presented a different perspective by proposing a model to measure the self-efficacy of the user, placing the system/technology under observation in the environment. It builds on the Social Cognitive Theory which states that environmental influence, personal factors and behavior exhibit triadic reciprocality. The resulting model (shown in Figure 8) shows support, others' use, and encouragement by others, to be positively affecting self-efficacy and outcome expectation. Self-efficacy also positively affects outcome expectation. Depending on the efficacy, it may cause affection or anxiety for usage of the system/technology.

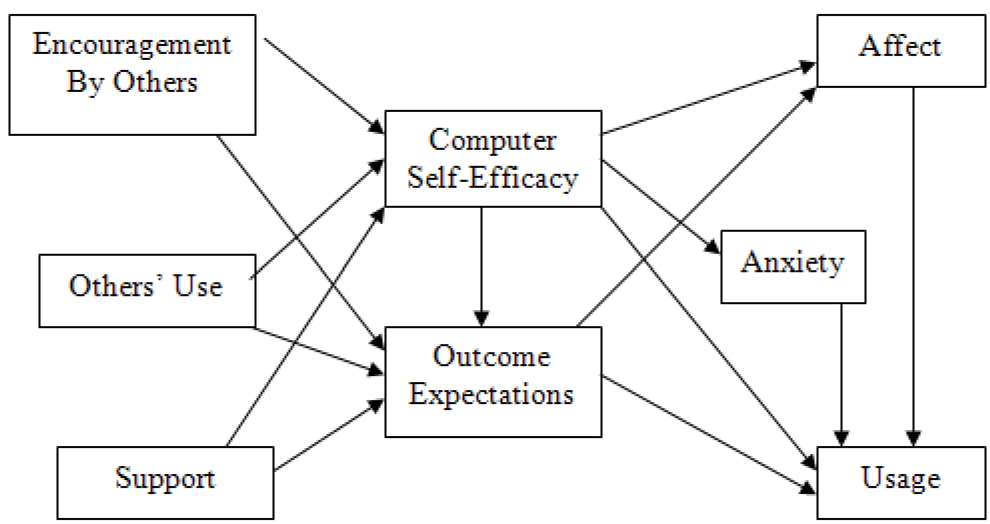

Figure 8: Computer Self-efficacy Model

However, during the course of user studies, they discovered that support could negatively affect efficacy. An example is when a user finds something to be tough and the support personnel consider it to be trivial and fix it instantly. Compeau et al. [6] validated this model using a longitudinal study.

The TAM could not keep up with changes in the field of IT. Taylor and Todd [21] put the TAM (Figure 6), the TPB (Figure 7), and a decomposed variant (Figure 9) of it, to the test. Their differences were identified, and the fact that TAM is not specialized to accommodate present day needs became clear from the fact that the authors state that the model has reasonable explanatory power, but has not produced consistent results in all cases. Also, they point out that there are quite a number of external variables that affect usage – system design characteristics, training, documentation, and other types of support. While the TPB identifies the first-level affecting factors of behavioral intentions, the decomposed model breaks down these factors to another set of dependencies. After user studies, the authors analyzed and found that the decomposed version of the TPB works best among the three. The authors emphasized that these models have to be updated with improvements in technology.

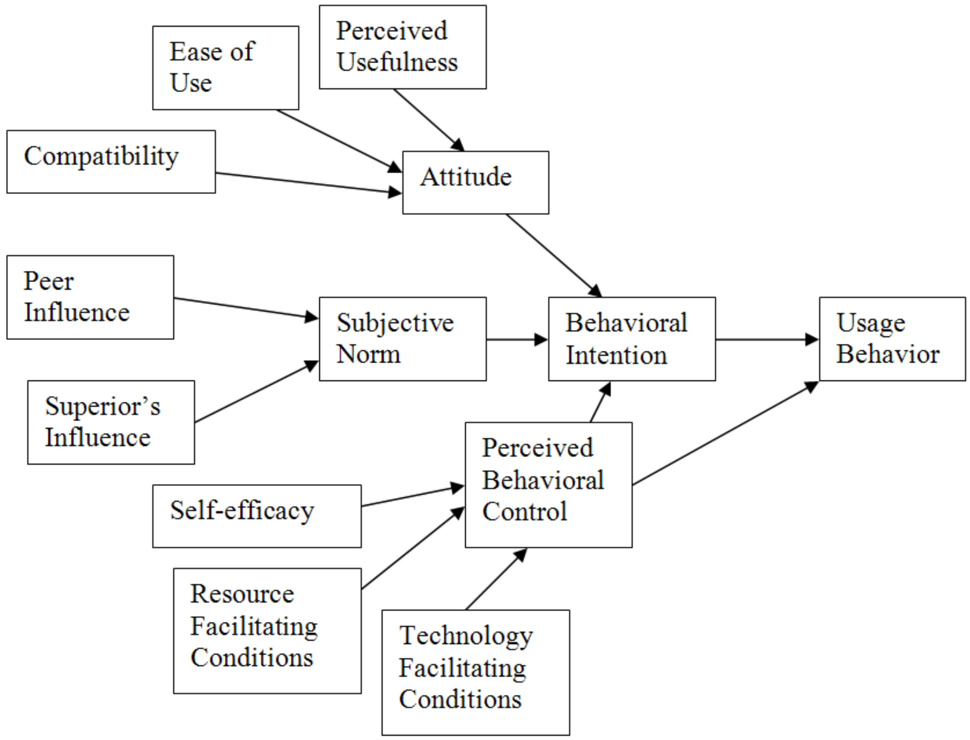

Figure 9: Decomposed Theory of Planned Behavior

The models discussed so far had been developed for situations where users were introduced to new systems. The importance of prior experience was not taken into account. This was becoming significant as the problem of being introduced to IT shifted to being introduced to a competitor's product, or a new version of an existing product. Taylor and Todd assessed IT usage with prior experience [22] taken as a determinant in the TAM. They tried to assess if TAM could predict behavior for inexperienced users and if the determinants of IT usage are the same for experienced and inexperienced users. In particular, the effect of experience on Perceived Behavioral Control (PBC) on behavior was studied. The authors noted that the knowledge gained from past behavior helps to shape intention because past experience may make low probability events more salient, ensuring that they are accounted for in the formation of intentions. To help TAM accommodate experience as a factor, PBC was linked to behavior, as can be seen in Figure 10. The authors observed that the PBC had less impact on intention but more impact on behavior for inexperienced users, who rely more on Perceived Usefulness.

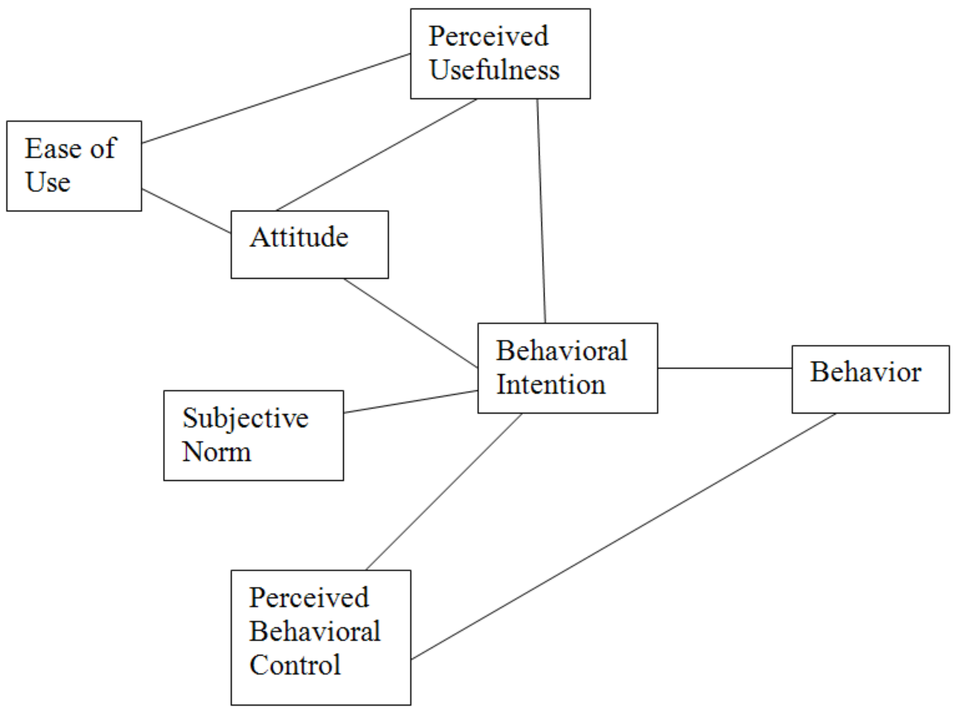

Figure 10: TAM Augmented with Experience

As indicated earlier, with time, users had become experienced with computers which necessitated that these models be blended into the software engineering life cycle. Davis et al. [9] improved upon the existing TAM to produce two versions of it – one that could be used pre-implementation, and one that could be used after implementation of the system under study.

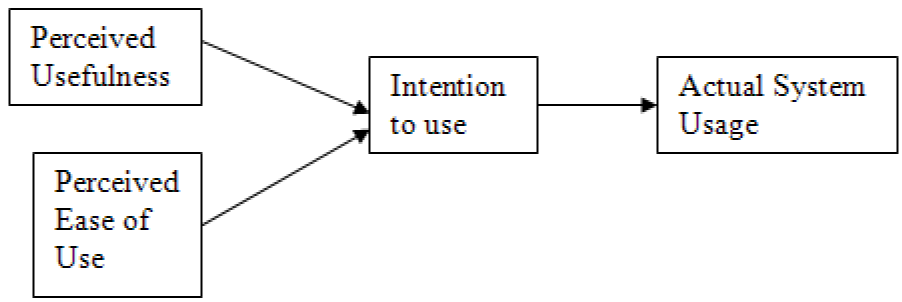

Figure 11: Pre-Implementation Version

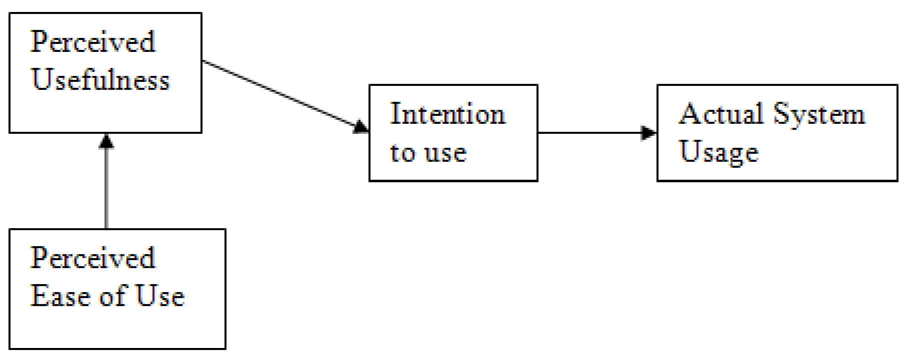

Figure 12: Post-Implementation Version

The pre-implementation model (Figure 11) predicts acceptance with Perceived Usefulness (U) and Perceived Ease of Use (E), while the post-implementation (Figure 12) model predicts acceptance with Perceived Usefulness (U) alone. This suggests that users would lay emphasis on ease of use if competing products are equally useful. Otherwise, proven utility can have a significant impact on the user's intention to use the system. Szajna [20] empirically evaluated this idea of having two versions and compared it with the original TAM. The author pointed out the earlier work of Ajzen [2] which says "Information gathered from experience over a period of time certainly has the potential for changing future intentions". Hence, the effect of intentions on usage becomes less with experience. The authors suggested reverting to TAM augmented with actual system usage for pre- and post-implementation. They directed future researchers to use measures other than usage to measure acceptance. They cited an example of tax software whose acceptance cannot be measured with usage frequency, and where reaching an accurate result can be used as a measure instead.

Davis [9] had earlier identified the need to fit in the role of Intrinsic Motivation in TAM. This was investigated by Venkatesh [25]. Seven different training methods were identified – tutorial, courses/lectures/seminars, computer-aided instruction, interactive training manual, resident expert, help component, and external training. These methods lay emphasis on communication of knowledge to users. The author proposed that the training method would make a difference and suggested a game-based training method to increase the Perceived Ease of Use (E) component in TAM. This training method has disadvantages in that it is possible for users to dismiss such training as non-related to work. Nevertheless, the results from studies conducted favored game-based training. However, a point to note in this study is that the age of the participants is not considered.

All along, the factors that would contribute to Perceived Usefulness (U) of the system in the TAM model were not comprehensively listed. Venkatesh and Davis [26] addressed this, and extended TAM to form TAM2. They also introduced the concept of moderating variables, namely Experience and Voluntariness. Moderating variables allow one to view different cross-sections of the user population. The responses of each kind of users can provide interesting results. Their work involved a comprehensive analysis of TAM for modern needs. The study was spread over three phases – before implementation of a system, immediately after implementation of the system, and after the user gets comfortably acquainted with the implemented system. Studies conducted by Hartwick and Barki [15] suggested that Subjective Norm had a major impact on

Perceived Usefulness in mandatory settings. The authors argue that the image and elevated status resulting from using a technology adds impetus to Perceived Usefulness. The authors also claim that theory and evidence exist that suggest that the direct effect of Subjective Norm on intentions may subside over time with increased system experience. Also, the authors identify social cognitive attributes in the present time that affect Perceived Usefulness – Job Relevance, Output Quality and Result Demonstrability, in addition to the existing Perceived Ease of Use. This model worked fine across all three phases. The model is shown below.

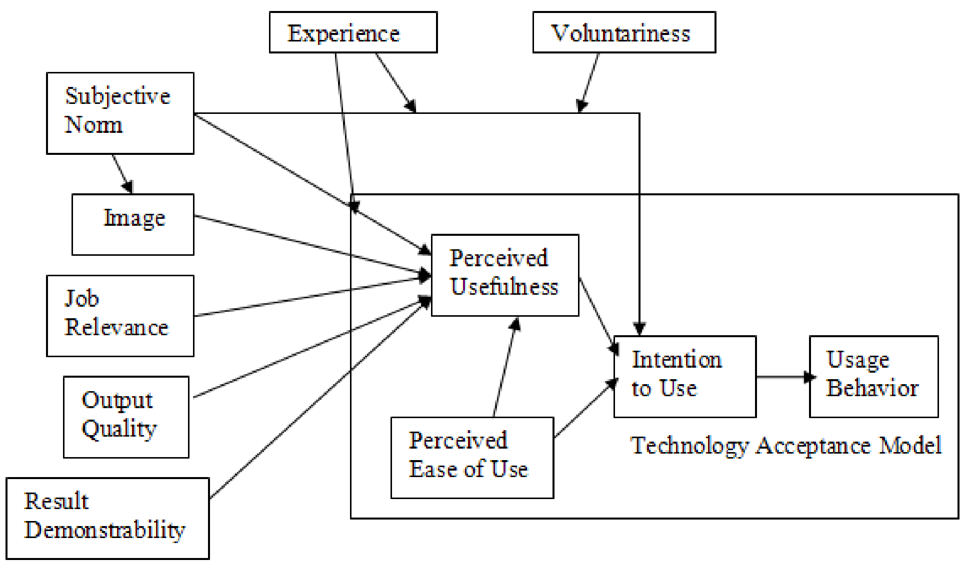

Figure 13: Extended TAM

Different researchers, over a period of time, have suggested various augmentations to TRA, TAM, and TPB. Some have devised different models by themselves. Each derived model has its own share of pros and cons. To redirect these differing views onto a single track and to derive knowledge from associated frameworks, Venkatesh et al. studied eight popular models, and came up with a

Unified Theory of Acceptance and Use of Technology (UTAUT) to streamline them all [27]. The concepts underlying all frameworks contain interactions between three entities – Individual Reactions to Using Information Technology, Intentions to Use Information Technology, and Actual Use of Information Technology. The models studied were TRA, TAM/TAM2, Motivational Model (MM), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), TPB/Decomposed TPB, Social Cognitive Theory (SCT), and Combined TAM-TPB. Figure 14 shows the model that the authors proposed as a unified framework.

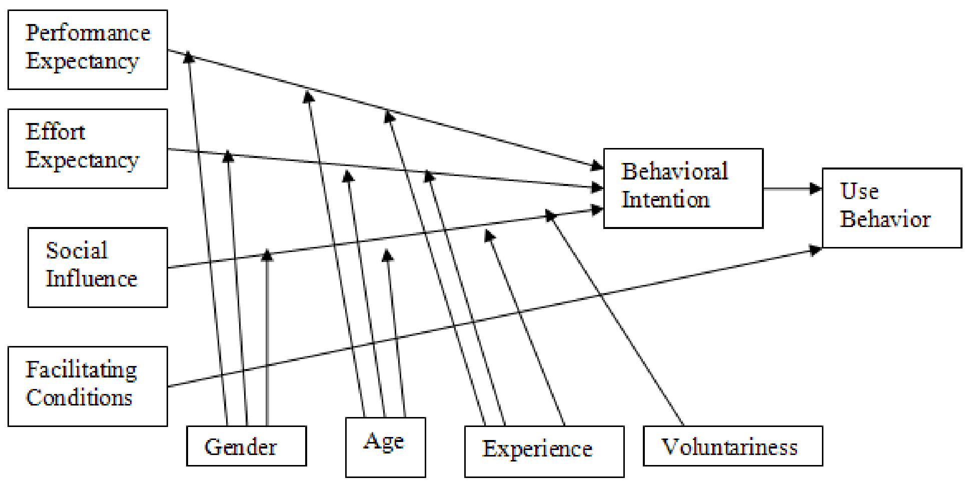

Figure 14: Unified Theory of Acceptance and Use of Technology

The UTAUT framework proposes Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions to be affecting Behavioral Intention while being moderated by Gender, Age, Experience and Voluntariness. The Behavioral Intention thus formed along with the Facilitating Conditions affect the Use Behavior. This model was subjected to empirical studies and it performed well. The concept of moderating variables is in keeping with the expansion of technology to a wider audience.

The discussion so far has focused on exploring user behavior. The following paragraphs describe methods used in defining and measuring the success of an Information System.

The work done by De Lone and Mc Lean [10] is considered to be a milestone in modeling success of Information Systems. The model proposed by them is shown in Figure 15.

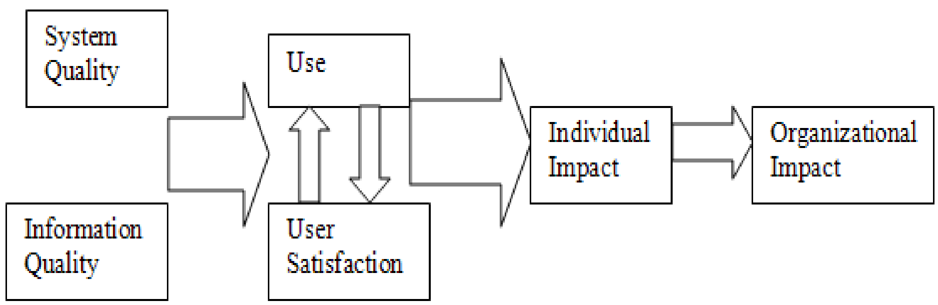

Figure 15: DeLone and McLean's Model of IS Success

Seddon [18] observes the pitfalls of this model, and cites examples of where it could be misleading. He then respecifies a model for measuring IS success which is shown below. The details of this model are available in the next section.

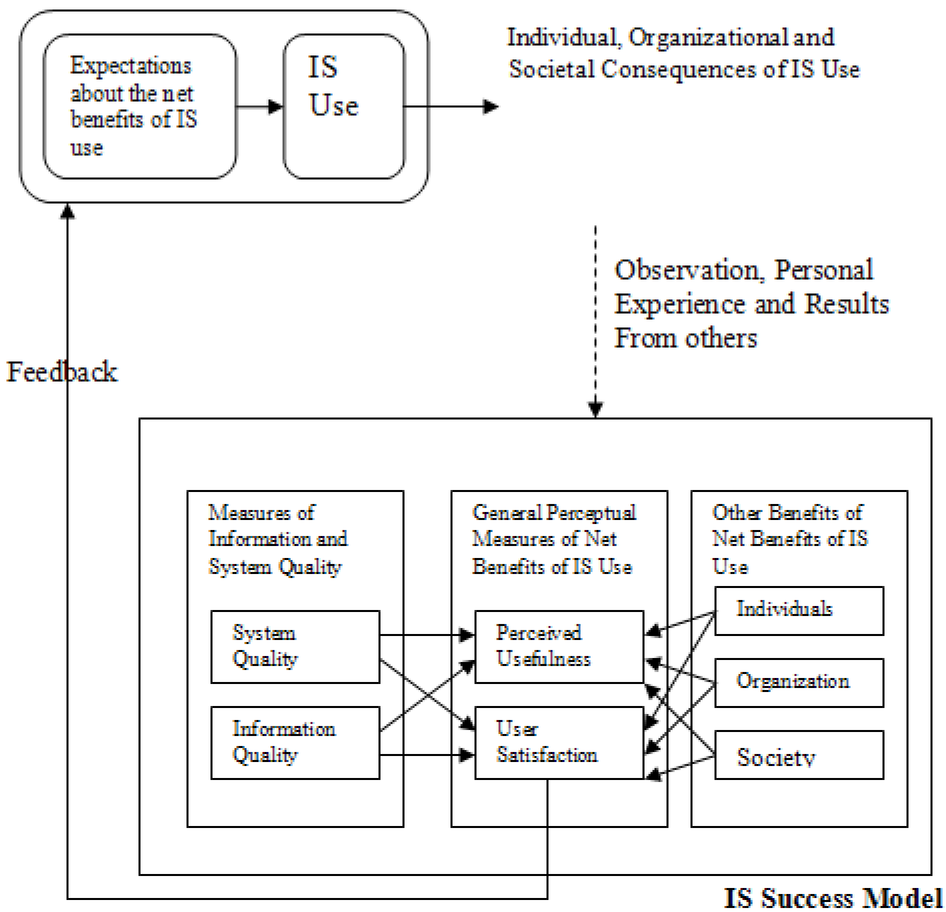

Figure 16: Seddon's Model of IS Success

However, a key observation that can be made is that the models mentioned above are more suited for industry-based settings. In the academic environment, especially in that of Digital Libraries, some domain-specific quality metrics have been proposed. Gonçalves, in his dissertation on formalizing the definition of digital libraries [13], specifies a set of quality metrics for digital libraries along with their precise definitions.

Shen et al. [19] studied IS success, to adapt it to measure Digital Library success [new paper]. Accordingly, Perceived Usefulness from the IS success model was replaced by Performance Expectancy from the UTAUT model. These terms are equivalent by definition. However, this enabled us to include the moderating factors presented by the UTAUT model. Also, the factor of Net Benefits to Different Stakeholders from the IS Success model was replaced by Social Influence that is borrowed from the UTAUT model. To break down System Quality and Information Quality into constructs of relevance in the Digital Library domain, quality metrics specified by Gonçalves [13] were used.

This section presented the findings of various authors and also showed how researchers have gone about modeling user communities.

CHAPTER 4: MODEL FOR THE CS STUDENT COMMUNITY

This section explains how a model was arrived at for explaining the behavior of the Computer Science student community. Findings from the literature explained in the previous section, known characteristics of the community in question, and input from Human Computer Interaction (HCI) experts contributed to the formulation of the model.

A brief explanation of the UTAUT model proposed by Venkatesh et al. [27] was provided in the previous chapter (Figure 14). UTAUT attempts to streamline and unify various models that attempt to explain Behavioral Intention. The model suggests that Performance Expectancy, Effort Expectancy, and Social Influence will effect Behavioral Intention, which, along with Facilitating Conditions, effects Use Behavior. The effects of these factors are moderated by Gender, Age, Experience, and Voluntariness.

Performance Expectancy is defined as the degree to which an individual believes that using the system will help him or her to increase productivity at work. This term is used as a normalizing factor for various names used in each one of the eight models that the UTAUT [27] attempts to normalize. *Effort Expectancy* is defined as the effort required on the part of the user to use the system to reach his/her goals. *Social Influence* is defined as the degree to which an individual perceives that people significant to him/her would expect him/her to use the new system.

According to the model that Seddon formulated to measure the success of Information Systems, the factors that contribute to that success are shown in Figure 17.

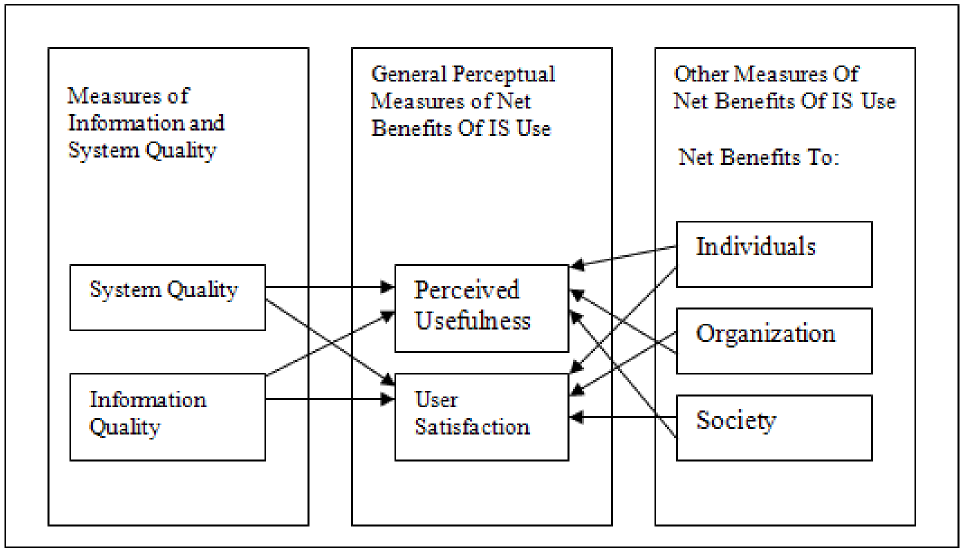

Figure 17: IS Success

Information Quality is concerned with relevance, timeliness, accuracy, etc. of information generated by the Information System. *System Quality* is concerned with aspects such as the bug-free nature of the system, the consistency of the user interface, ease of use, quality of documentation, and sometimes, quality and maintainability of the program code.

The model suggests that the General Perceptual Measures of Net Benefits of IS Use are chiefly affected by the Measures of Information and System Quality, and the net benefits to other stakeholders.

To measure the success of Digital Library systems, this IS Success model needs to be adapted accordingly. The Information Quality and System Quality constructs are decomposed with metrics that are best suited to measure the quality of Digital Library systems. These metrics are borrowed from Gonçalves' Quality Model for Digital Libraries [14]. Gonçalves has defined a life cycle for a digital object. Each digital object goes through four phases – creation, distribution, seeking and utilization, and different metrics can be used to measure the quality of it during each of these stages. This is shown in Figure 18 below:

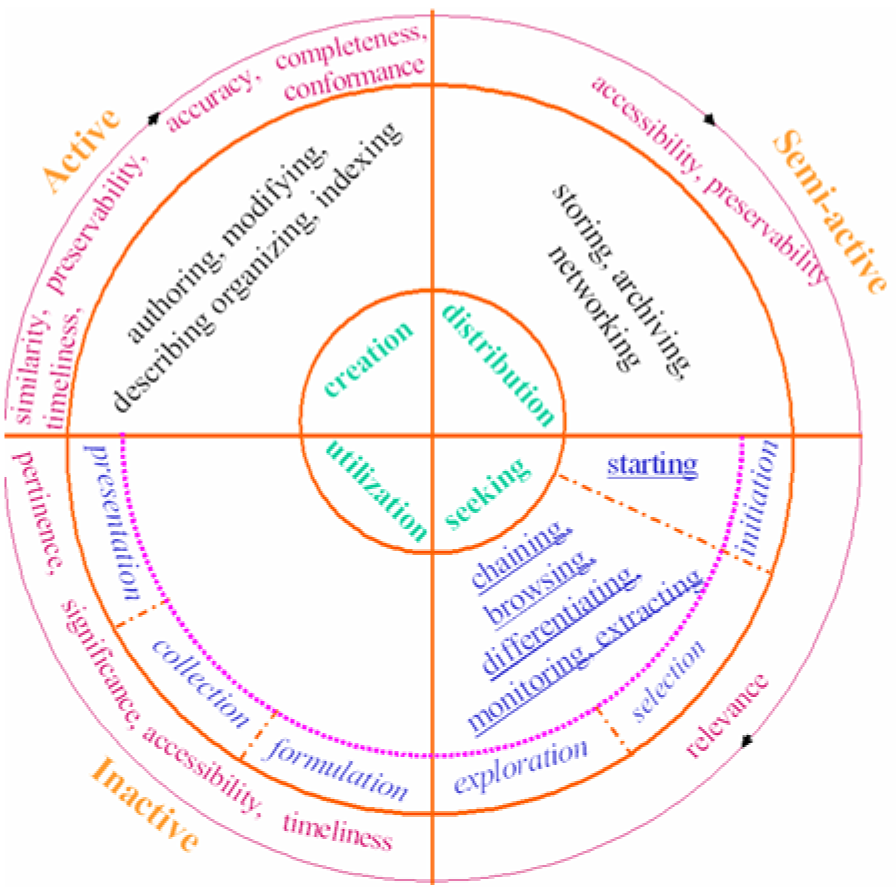

Figure 18: Life Cycle of a Digital Object (reproduced with permission of author)

A meta-search engine is a container of digital objects. It is available for users after development. Hence, the distribution and creation phases are irrelevant. This would be the case for any similar service. Hence, the relevant phases of the life cycle are *seeking* and *utilization* which can be broken down into measurable constructs (Figure 18).

The model proposed to measure DL success by Shen et al. [19] is shown in Figure 19.

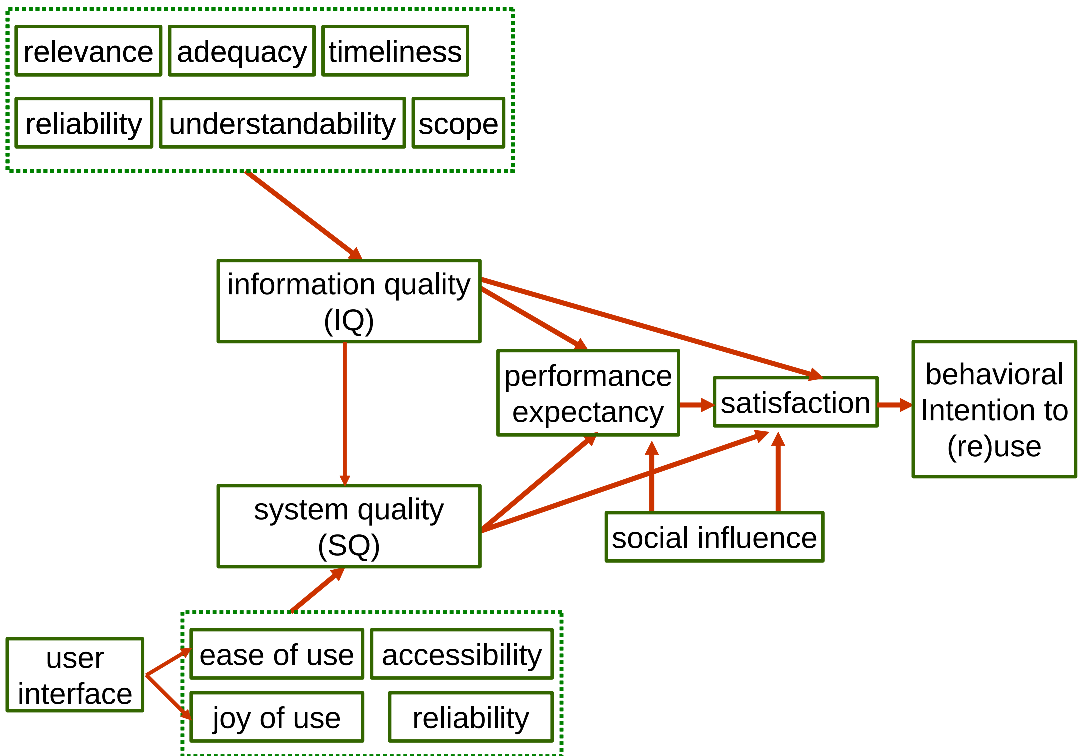

Figure 19: Model to measure DL Success (reproduced with permission of author)

This model uses metrics from the life cycle of a digital object provided by Gonçalves [13]. However, this model by itself is generic for a given intended audience. It needed to be adapted to fit the Computer Science student community that was to be studied.

As can be seen, this model does not build upon the concept of moderating variables introduced by the UTAUT framework [27]. The fact that students all over the world do not share the same traits had to be considered as well. Thus, in addition to Gender, Age, Voluntariness, and Experience, Race is also included as a moderating variable.

The DL Success Model [19] does not consider the effect of review of a digital object on information quality. The knowledge of an artifact being reviewed by someone in the past is important to the student when selecting from a given set of choices. A construct named Vettedness is added for this purpose.

Also, the DL Success Model [19] misses out constructs such as Support available to the user in the form of documentation (the 'Help' feature) and Choices available for users of varying expertise. These factors affect the System Quality as perceived by the student user.

Usability engineering emphasizes having interfaces for the common user and the expert user. For most systems, the Computer Science student can be considered an expert who would not mind if the system was not very user-friendly, as long as he/she gets the desired outcome. In other words, the role of System Quality in the model is minimal, but cannot be neglected. So, the effect of System Quality on Performance Expectancy is removed. The Computer Science student being an expert, the effect of Social Influence could affect the perceived Performance Expectancy, but the choice of Satisfaction remains largely unaffected.

The model for the Computer Science student community thus formed is shown in Figure 20.

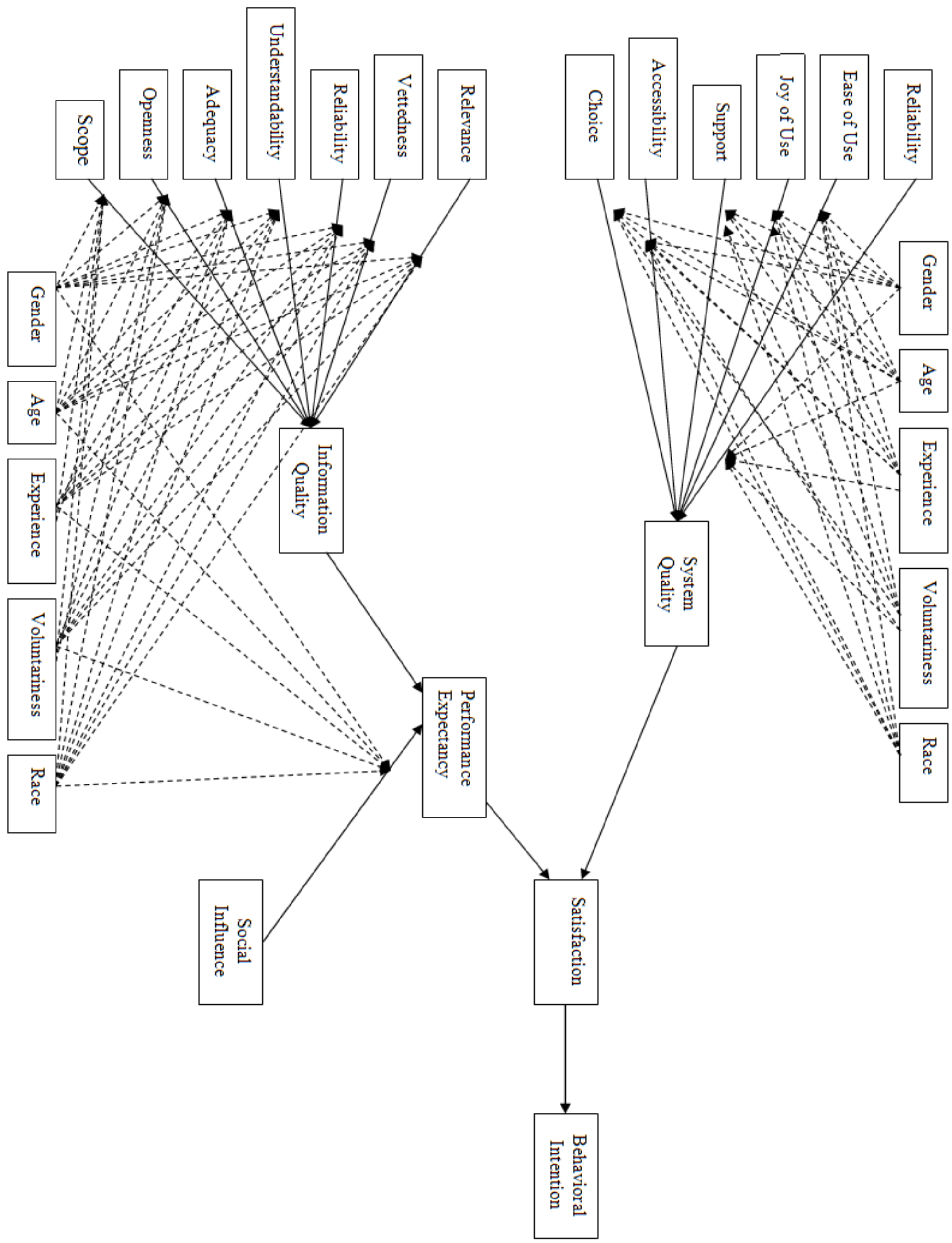

Figure 20: Model of Computer Science Student Community

An explanation of each factor involved in formulating Information Quality and System Quality in the context of a meta-search engine follows:

- *Relevance* – This corresponds to how much the results are related to the user's particular query. Gonçalves [13] defines this to be a characteristic that can take values of either 0 or 1. However, from speaking with users of different search engines, it was found instead that they considered some results to be partially relevant, almost relevant, and so on.

- *Adequacy* – When a user issues a query, he/she gets to see an information snippet with each result and upon clicking a particular result, more information about the resource itself is displayed, along with where the resource can be located. When a user wants to use a search engine for his/her research, he/she wants to see more information about the data itself. The sufficiency of this information is essential for determining if the quality of information is high.

- *Understandability* – The search engine provides multiple views to the user. The organization of results in each view was explained in Section 2. However, this organization should make sense for the users to benefit. This aspect measures how well the users comprehend the results as the developers want them to.

- *Reliability* – The search engine provides results to the user. However, in some cases, the location of the resource indicated by the search engine or the meta-data provided about a resource might be wrong. A search engine should minimize such problems.

- *Vettedness* – When a resource found by a search is endorsed by someone significant in its field, it might be considered desirable. However, this is not the case always. For instance, a philosopher might not be interested in the rating by a practitioner.

- *Openness* – Researchers may prefer an open source system so that they can extend or modify it to suit their requirements. They also may prefer to know details of the operation of a system so as to make maximum use of it.

- *Scope* – Users prefer more rather than less data to search on. Digital Library search engines obtain data from various providers. Examples of such providers would be the IEEE, ACM, etc. Users might want to know the sources considered by a particular search engine.

An explanation of each factor involved in formulating System Quality follows:

- *Ease of Use* – Users prefer search engines that are not difficult to work with. Hence, this is a factor that needs to be considered.

- *Joy of Use* – Users are motivated by a ‘cool’ factor to get started on a system and to continue using it. They prefer when using the system is a pleasurable experience.

- *Support* – Users might require help to know how to go about doing certain operations. The availability and the quality of such help might be an important factor in determining System Quality.

- *Accessibility* – This refers to the responsiveness of the system. This includes the time taken for the homepage to load, and the time the search engine takes to retrieve results for issued queries.

- *Reliability* – In the context of system quality, this refers to the absence of bugs in the system. The users are bound to dislike a system that malfunctions often.

- *Choice* – Users might prefer having more options related to controlling how they interact with the system.

This section explained how a model was formulated to explain the behavior of the Computer Science student community, and provided a detailed explanation of the constructs into which the model is decomposed. Based on that, we prepared a questionnaire to obtain responses from sample users of the community. The following section explains how this was done.

CHAPTER 5: QUESTIONNAIRE AND IRB APPROVAL

This section explains how a questionnaire corresponding to the model derived in the previous chapter was formulated. The questionnaire was then approved by the Institutional Review Board (IRB) at Virginia Tech.

A chief concern was if each participant would understand the question as the researcher expected. Consequently, an iterative approach was followed to formulate the questionnaire. It was subjected to pilot testing where the participant had to think aloud what he/she understood from each question. The shortcomings of the questions were noted, and the next version was developed.

Questions were formulated after discussions with eligible subjects. It was suggested implicitly and explicitly by the participants that the questions pertaining to a particular factor in the model also needed some assistive questions or statements. The assistive questions could be something very specific to the system being tested for acceptance, about a particular task that could be done by the user to verify the meaning of the factor in the model. For example, assistive statements to accessibility would be "The text and images associated with the pages of the search engine loaded quickly on an average" followed by "Overall, this search engine appears to be responsive.". These assists helped the participant to form an idea of what exactly the factor meant in terms of the meta-search system, and then reach a decision on that factor.

The questions were formulated in such a way that the answers could fit into the standardized 7-point Likhert scale. The questionnaire that was obtained out of this process is available as Appendix A.

Since the user study would require human subjects, approval from the Institutional Review Board had to be obtained. The questionnaire along with the mode of study and an estimate of how many subjects would be required was submitted. The documents pertaining to the IRB are attached in Appendix C.

CHAPTER 6: USER STUDY

This section describes how the user study was conducted, and how, when, and where the questionnaire, whose formulation was discussed in the previous chapter, was served.

To study the satisfaction and acceptance of the meta-search system, students with a background in Computer Science were invited. The subjects were over eighteen years in age, and were either undergraduate or graduate students.

The users were asked to use the meta-search engine along with the existing search engine that operated on the same data sets, from http://www.citidel.org. The study was conducted over a period of 12 days. The users were required to use both systems, and then answer a questionnaire that was made available online. To lessen invalid responses, the questionnaire was made available only 7 days after the user study started.

The questionnaire was broken down at the level of factors that are present in the model (Figure 20), and the order in which these factors were presented to the user was randomized. Also, since there were a number of factors in the model, the user was presented questions pertinent to one factor at a time, and he/she had the option to save the responses provided so far, and come back later to continue working on it.

The questionnaire contains a section that asks for demographic information, and confirms if they had used the existing search engine. From then on, the responses were on a 7-point Likhert scale that included Strongly Agree, Somewhat Agree, Slightly Agree, Neutral, Slightly Disagree, Somewhat Disagree, and Strongly Disagree as the options. To reduce the likelihood of users picking the wrong choice by mistake, the responses were color-coded - the responses were coded from green (for "Strongly Agree") to orange (for "Strongly Disagree") with progressive shades.

Advertisements were sent out periodically on the mailing list of CS-Students. A class of CS undergraduates was asked to take this up as an assignment. Credits were awarded to those undergraduates who took up the user study.

At the end of the study, a total of 111 responses were received. Out of these, 4 responses were considered invalid because the users were professors, and did not fit into the targeted community.

CHAPTER 7: ANALYSIS OF RESULTS

This section describes the method that was used for analysis of the results, and the findings from the questionnaire responses obtained.

The model hypothesized in Chapter 4 (Figure 20) shows each factor in the model to be affected my multiple independent factors (regressor variables), except for the factors at the edges. This naturally leads us to a multiple linear regression model. Mathematically, Information Quality, System Quality, Performance Expectancy, Satisfaction, and Behavioral Intention can be expressed in the form

$$y = B_0 + B_1x_1 + B_2x_2 + \ldots + \varepsilon \tag{1}$$

where y would be each one of them, while x_1 , x_2, etc. would be the factors that affect them, i.e. the ones that have outward arrows. This is an equation of a plane of which B_0 is the *intercept*, ε is a random error term, and terms B_1, B_2, B_3 are known are *partial regression coefficients*, the name arising from the fact that B_1 measures the exact change in y per unit change in x_1 and so on. The random error term ε can be removed from the equation if we assume the expected value of the error term to be zero, i.e., $E(\varepsilon) = 0$.

For example, Information Quality is hypothesized to be affected by Relevance, Adequacy, Understandability, Reliability, Vettedness, Openness and Scope. This would mathematically translate into:

$$\textit{Information Quality} = B_0 + B_1(\textit{Relevance}) + B_2(\textit{Adequacy}) + B_3(\textit{Understandability}) + B_4(\textit{Reliability}) + B_5(\textit{Vettedness}) + B_6(\textit{Openness}) + B_7(\textit{Scope})$$

(2)

Similarly, with different values for B_i,

$$System\ Quality = B_0 + B_1(Ease\ of\ Use) + B_2(Joy\ of\ Use) + B_3(Support) + B_4(Accessibility) + B_5(Reliability) + B_6(Choice)$$

(3)

$$Performance\ Expectancy = B_0 + B_1(Information\ Quality) + B_2(Social\ Influence)$$

(4)

$$Satisfaction = B_0 + B_1(System\ Quality) + B_2(Performance\ Expectancy)$$

(5)

$$Behavioral\ Intention = B_0 + B_1(Satisfaction)$$

(6)

However, the model hypothesizes that the moderating variables would have an effect on each one of these. Mathematically, this means that the coefficients would be different when the responses are divided into different sets by gender, age, voluntariness, and race.

The partial regression coefficients can be obtained by using the *method of least squares* explained below. The model can be proved to be valid if all the models mentioned above in the form of equations are proven to be significant. The tests of significance are at two levels – one for the fit of the model, and one for the significance of each regressor variable. The tests used to assess these measures are known as the *F-test* and the *least square estimated standard error*.

The method of least squares requires that n observations be present such that $n > k$ where k is the number of partial regression coefficients (or, the number of factors). If the responses provided by one user constitute one observation, the observations are

$$y_i = B_0 + B_1 x_{i1} + B_2 x_{i2} + \ldots B_k x_{ik} + \varepsilon_i \text{ where } i = 1, 2, 3, \ldots n \text{ and } n > k$$

This can be expressed in matrix notation as

$$Y = X\beta + \varepsilon$$

where Y is an $(n \times 1)$ vector of the observations, X is an $(n \times p)$ matrix of the levels of the independent variables, β is a $(p \times 1)$ vector of the regression coefficients, and ε is a $(n \times 1)$ vector of errors.

It is required to find the vector of least square estimators, β, that minimizes

$$L = \Sigma \varepsilon_i^2 = \varepsilon'\varepsilon = (Y - X\beta)'(Y - X\beta)$$

$$\text{and } j = 1 \text{ to } k$$

L needs to be minimized. Montgomery and Runger [17] show that this can be minimized by solving the equation

$$X'X\beta = X'Y$$

which leads to

$$\beta = (X'X)^{-1} X'Y$$

(7)

The fitted model with the regression coefficients obtained from solving equation 2 is:

$$\hat{y}_i = \beta_0 + \Sigma \beta_j x_{ij} \quad \text{where } i = 1, 2, 3, \ldots n \text{ and } j = 1, 2, \ldots k$$

To obtain the significance of each factor in the model, the estimated standard error of each β_j is used, which is denoted by $se(\beta_j)$. Each β_j being considerably larger than $se(\beta_j)$ is an indication of reasonable precision of estimation. Montgomery and Runger [17] provide a detailed explanation of how these standard errors are arrived at.

The test for significance ascertains that a linear relationship exists between a subset of the regressor variables and the response variable. There could be two possible hypotheses for any given relationship:

$$H_0: B_1 = B_2 = B_3 = \ldots = B_k = 0$$

$$H_1: B_j \neq 0 \text{ for at least one } j$$

The sum of squares of all responses is partitioned into sum of squares due to regression (explained below) and a sum of squares due to error, i.e.

$$SS_T = SS_R + SS_E \tag{8}$$

The method of arriving at SS_E is explained by Montgomery and Runger [17] in detail. With SS_R and SS_E, the mean square values of them can be calculated as MS_R and MS_E respectively. The ratio of MS_R to MS_E gives a value that can be used to assess the goodness of fit, and is known as the *F value* [17]. The significance of the F-value, if lesser than the critical value of 0.05, causes us to reject H_0 implying that the model is significant overall [16].

To arrive at the values for the partial regression coefficients in each of equations and the estimated standard errors of the least square estimators, the Analysis ToolPak™ in Microsoft Excel™ 2003 was used. Of the answers provided by the user, answers to assistive questions were ignored because they were provided largely for the purpose of better understanding by the user and their effectiveness was validated with pilot studies described earlier. Responses provided to the direct relevant questions were used for the analysis. Upon providing the values for the known *y* values, and the known *x* values obtained from the study, and running a regression analysis, a multitude of statistics resulted, including the values in which we are interested, namely *ß* and *se(ß)* (standard error of *ß*).

The following paragraphs explain how the data was split across moderating variables, and how the hypothesized model (equations 2 through 6) was verified for each one of the cases.

In keeping with IRB regulations, the obtained results were processed to make them anonymous so that the users could not be personally identifiable. The received responses can be classified in different ways as shown below.

- Gender-wise, 91 males and 16 females responded.
- Experience-wise, 55 undergraduates, and 52 graduates responded.
- Of the 107 students who took part in the study, 41 of them were non-voluntary, and 66 of them were voluntary users. The reason for considering them to be so is explained later in this chapter.

- Age-wise, only 4 of the 107 participants were outside the 20-30 range.

These classifications enable study of the validity of the effect of moderating variables.

In the hypothesized model (Figure 20) introduced in Chapter 4, five moderating variables were introduced – gender, age, experience, voluntariness, and race. Of these, the effect of gender and age cannot be learned using the results of this study because of very few responses. However, the significance of these moderating variables has been identified in UTAUT by Venkatesh et al. [27], so including them in the model seems justified.

No questions pertaining to race were asked during the user study. The study could not be conducted across different nations for logistical reasons. But, the known fact that teacher-student relationship is different in different cultures gives confidence regarding including race as a moderating variable.

The validity of the model could be verified regarding the effect of experience and voluntariness.

However, though the number of participants was over 100, the entire Computer Science student community is very much larger, so analysis of the significance of the regressor variables was not considered to be justified. Hence, fit of the model alone is considered.

The results of regression analysis for each of Information Quality, System Quality, Performance Expectancy, Satisfaction and Behavioral Intention are attached in Appendix B. The partial regression coefficients and the fit of the model alone are discussed below.

Experience

Of the 107 students who took part in the study, 55 of them were undergraduates, and 52 of them were graduates. Graduate students can safely be considered to be more experienced than undergraduates.

The results for regression analysis of equation 2 that pertains to Information Quality for graduate students was

$$\textit{Information Quality} = 0.4404 + 0.4142(\textit{Relevance}) + 0.0624(\textit{Adequacy}) - 0.0184(\textit{Understandability}) + 0.2654(\textit{Reliability}) - 0.0535(\textit{Vettedness}) + 0.1501(\textit{Openness}) + 0.0741(\textit{Scope}) \quad (9)$$

while that obtained for undergraduate students was

$$\textit{Information Quality} = 0.1296 + 0.1824(\textit{Relevance}) + 0.1707(\textit{Adequacy}) + 0.1302(\textit{Understandability}) + 0.4382(\textit{Reliability}) + 0.0018(\textit{Vettedness}) + 0.1329(\textit{Openness}) - 0.0745(\textit{Scope}) \quad (10)$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 21 and 22.

The sign and magnitude for each coefficient in equation 9, versus in equation 10, indicate differences between students with different levels of experience, when determining the Information Quality of a system.

The fact that graduate students do not bother as much about understandability or reliability as do undergraduate students, suggests that as long as they achieve their desired outcome, they do not bother about how understandable or reliable is the help provided by the system. Higher importance is attached to scope by graduate students, suggesting that they do not want to miss out on anything, even at the cost of reliability or understandability.

The results for regression analysis of equation 3 that pertains to System Quality for graduate students was

$$\textit{System Quality} = 1.3928 + 0.0868\ (\textit{Ease of Use}) + 0.2425\ (\textit{Joy of Use}) - 0.0153\ (\textit{Support}) + 0.3602\ (\textit{Accessibility}) + 0.2304\ (\textit{Reliability}) - 0.2655\ (\textit{Choice}) \quad (11)$$

while that for undergraduate students was

$$\textit{System Quality} = 0.3769 + 0.4197(\textit{Ease of Use}) + 0.3899\ (\textit{Joy of Use}) - 0.0565(\textit{Support}) - 0.0826(\textit{Accessibility}) + 0.2216\ (\textit{Reliability}) + 0.0109\ (\textit{Choice}) \quad (12)$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 23 and 24.

It appears that with experience, the importance that the Computer Science student attaches to Ease of Use, Joy of Use, Support and Choice decreases, while the student is increasingly concerned about Reliability and Accessibility with regard to the quality of the system.

In other words, the new student seems to be more worried about achieving desired results and prefers an easy to use system. With experience, he/she gains confidence and worries more about the system always being accessible and reliable.

The results for regression analysis of equation 4 that pertains to Performance Expectancy for graduate students was

Performance Expectancy = 0.8656 + 0.6044 (Information Quality) + 0.1365 (Social Influence)

(13)

while that obtained for undergraduate students was

Performance Expectancy = 0.7211 + 0.5805 (Information Quality) + 0.2414 (Social Influence)

(14)

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 25 and 26.

Equations 14 and 15 show that social influence which could be from a peer or a professor does have an effect on the perceived Performance Expectancy which decreases with experience, while the effect of perceived Information Quality may increase.

The results for regression analysis of equation 5 that pertains to Satisfaction for graduate students was

Satisfaction = 0.0106 + 0.3874 (System Quality) + 0.5515 (Performance Expectancy)

(15)

while that obtained for undergraduate students was

$$Satisfaction = 0.5047 + 0.2065\ (System\ Quality) + 0.6990\ (Performance\ Expectancy) \quad (16)$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 27 and 28.

It seems that experienced students attribute more importance to System Quality than inexperienced students which might seem a bit contradictory. However, from equations 11 and 12, we see that graduates perceive System Quality more in terms of Accessibility and Reliability than factors such as Ease of Use and Joy of Use which mattered more for undergraduate students. This justifies the apparent contradiction that is seen from equations 15 and 16.

The results for regression analysis of equation 6 that pertains to Behavioral Intention for graduate students was

$$Behavioral\ Intention = 0.3361 + 0.9185\ (Satisfaction) \quad (17)$$

while that obtained for undergraduate students was

$$Behavioral\ Intention = 0.7387 + 0.8987\ (Satisfaction) \quad (18)$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 29 and 30.

Equations 17 and 18 reflect very similar attitudes between graduate and undergraduate students. A high level of satisfaction is required for them to use the system again. This suggests that Experience does not affect someone's intention to use a system again, when considering their satisfaction.

Voluntariness

Of all participants, 41 of them undertook the study as a part of an exercise in class, and received credit for filling out the questionnaire, while the remaining 66 of them undertook the study voluntarily. The ones who participated under the constraint of credit can be considered as involuntary participants.

The results for regression analysis of equation 2 that pertains to Information Quality for voluntary users was

$$\text{Information Quality} = 0.2319 + 0.3604(\text{Relevance}) + 0.1171(\text{Adequacy}) + 0.0043(\text{Understandability}) + 0.2856\ (\text{Reliability}) - 0.0198\ (\text{Vettedness}) + 0.1418\ (\text{Openness}) + 0.0535(\text{Scope}) \tag{19}$$

while that obtained for involuntary users was

$$\text{Information Quality} = -\ 0.1847 + 0.3099(\text{Relevance}) + 0.1198(\text{Adequacy}) + 0.0957(\text{Understandability}) + 0.4950\ (\text{Reliability}) - 0.1239\ (\text{Vettedness}) + 0.0264(\text{Openness}) - 0.0169(\text{Scope}) \tag{20}$$

The significance of the F-value for the model for voluntary users was less than 0.05, but it was not so for involuntary users. Details are available at Figures 31 and 32.

A closer inspection of the responses provided by most of the involuntary users suggested that the study being perceived as mandatory made them choose random answers to the questions. However, the fact that most of them had answered positively for questions pertaining to their satisfaction and behavioral intention, as shown later, suggests that their responses were dictated more by credit offered to them. This offers significant evidence to the strength of voluntariness as a moderating variable.

The results for regression analysis of equation 3 that pertains to System Quality for voluntary users was

$$\text{System Quality} = 1.0612 + 0.1849\,(\text{Ease of Use}) + 0.3754\,(\text{Joy of Use}) - 0.1027(\text{Support}) + 0.2505(\text{Accessibility}) + 0.1338\,(\text{Reliability}) - 0.0514\,(\text{Choice}) \qquad (21)$$

and that for involuntary users was

$$\text{System Quality} = 1.7020 + 0.2145\,(\text{Ease of Use}) + 0.3609\,(\text{Joy of Use}) + 0.0637(\text{Support}) - 0.0064\,(\text{Accessibility}) + 0.2449\,(\text{Reliability}) - 0.3092\,(\text{Choice}) \qquad (22)$$

The significance of the F-value for the model pertaining to voluntary users was less than 0.05, while the model pertaining to involuntary users was 0.059. Details are available at Figures 33 and 34.This implies that it is reasonable to endorse the model of equation 21, but less reasonable to endorse the model of equation 22.

It can be seen that irrespective of Voluntariness, there is not a positive effect of Choice on the perception of System Quality. But, Voluntariness may influence the user's perception of Accessibility. Perhaps, users who were taking up the study for credit were unconcerned about the system being accessible after the study was done. As expected, voluntary users associated a somewhat low priority to Support being provided as long as the system was accessible and reliable and gave them a relatively pleasurable experience.

The results for regression analysis of equation 4 that pertains to Performance Expectancy for voluntary users was

$$\textit{Performance Expectancy} = 0.7637 + 0.6815\ (\textit{Information Quality}) + 0.0803\ (\textit{Social Influence}) \tag{23}$$

while that obtained for involuntary users was

$$\textit{Performance Expectancy} = 0.7211 + 0.4796\ (\textit{Information Quality}) + 0.3173\ (\textit{Social Influence}) \tag{24}$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 35 and 36.

Voluntary versus involuntary users seem to perceive differently the factors that affect Performance Expectancy. The fact that the role of Social Influence is higher among the involuntary users when compared to the voluntary users supports the use of Voluntariness as a moderating variable. In case of voluntary users, as expected, Information Quality affects their perception of Performance Expectancy even more than for involuntary users.

The results for regression analysis of equation 5 that pertains to Satisfaction for graduate students was

$$Satisfaction = -0.3913 + 0.2850\ (System\ Quality) + 0.8422\ (Performance\ Expectancy) \quad (25)$$

while that obtained for undergraduate students was

$$Satisfaction = 1.4038 + 0.2073\ (System\ Quality) + 0.4189\ (Performance\ Expectancy) \quad (26)$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 37 and 38.

The effect of voluntariness is observed in these models also. The amount of importance associated by voluntary users to Performance Expectancy is more than double than that associated by involuntary users.

The results for regression analysis of equation 6 that pertains to Behavioral Intention for voluntary users was

$$Behavioral\ Intention = 0.3860 + 0.9144\ (Satisfaction) \quad (27)$$

while that obtained for involuntary users was

$$\textit{Behavioral Intention} = 0.8857 + 0.8677\ (\textit{Satisfaction}) \tag{28}$$

The significance of the F-value for both models was less than 0.05, hence proving the overall significance of the model. Details are available at Figures 39 and 40.

Equations 27 and 28 reflect very similar attitudes between voluntary and involuntary users. A high level of satisfaction is required for them to use the system again. This confirms the observations made about equations 17 and 18.

To view the estimated standard error of each regressor variable across the different models and moderating variables, see Appendix B that has the output of regression analyses run with Microsoft ™ Excel 2003. The estimated standard errors that are used to assert the significance of regressor variables might be significant in certain models which are in keeping with the discussion above, to the effect of moderating variables, and the size of the sample.

CHAPTER 8: CONCLUSION

This section reviews the work that was done as a part of this thesis, how the goals were realized, what findings were made, and what lies for researchers in this model in the future.

Existing models were studied, and a model thought to best portray the behavior of the Computer Science community was formulated. An iterative approach was followed and a questionnaire was constructed. Users were recruited, and a study was conducted. The results were used to validate the model. However, the hypothesized model predicts that Gender, Age and Race would be moderating variables which could not be validated based on the available data. However, they might be investigated as moderating variables in the future, based on results from previous studies and some known facts about teacher-student relationships across various cultures. Validation of the model was carried out using a multiple linear regression model. It could have been done using Partial Least Squares method explained by Montgomery and Runger [16] as well.

The validated model suggests that Computer Science students consider themselves to be experts and do not give much importance to the usability aspects of a system if they are going to get their desired results. Also, with experience, their self-confidence grows and their tendency to be influenced by people academically significant to them reduces.

To further establish this model as characterizing the behavior of the Computer Science student community, studies could be conducted to study the actual effects of gender, age and race. Also, this model could be tested for its validity against a different product designed for the Computer Science student community. The outputs from these studies might help refine this model further.

The regression equations obtained for the model could be used to prioritize development of aspects of a system that is being targeted at the Computer Science student community. For instance, it seems more important for a system to be more reliable and accessible than very user-friendly.

Another observation that could researchers should consider for future studies is that participation in return for credit may not ensure that users participate in a study whole-heartedly.

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APPENDIX A

The following was the questionnaire that was used for the user study.

No.	Question	Ranking/Response
1. Demographic Information		
1	Gender	Male | Female
2	Age	___ years
3	Specialization	Computer Science | History
4	I am a(n)	Undergraduate | Graduate | Professor
5	I am receiving credits for participating in this user study.	Yes | No
6	I use search engines for my research	Many times a day | … | Never
Search engines are primarily used for two purposes in research Locating - finding an item whose identity is already known (e.g., searching for a paper whose title is already known) Exploring - finding identities of items of interest (e.g., searching for various papers on a particular topic)		
7	My relative usage of search engines for locating versus exploring would approximately be	100-1 | 75-25| 50-50| 25-75 | 1-100
8	I have used CITIDEL/AmericanSouth.	Yes | No
2. Information Quality		
2.1 Adequacy of Meta-data When I search for something, the results are laid out in a page. When I click on one of the results, details about the item(which could be a Microsoft Word document / Image / Video / Audio / PDF document) are displayed, which includes the location that actually contains the item .		
2.1.1	The detail that I get to see about the item of my interest is sufficient for my needs.	Strongly agree | ... | Strongly disagree
2.1.2	The detail that I get to see about the item of my interest is complete for my needs.	Strongly agree | ... | Strongly disagree
2.1.3	In addition to the details, I would like to see if I have unrestricted access to the item.	Strongly agree | ... | Strongly disagree

2.1.4	From my experience, I found the details available about items to be adequate for my needs.	Strongly agree | ... | Strongly disagree
2.2 Relevance Search engines are primarily used for two purposes in research Locating - finding something whose identity is already known(e.g. searching for a paper whose title is already known) Exploring - finding identities of resources of interest(e.g. searching for various papers on a particular topic)		
2.2.1	When I was locating a particular item, it was within the first few results.	Strongly agree | ... | Strongly disagree
2.2.2	When I was exploring for items on a topic, I found the results to be very pertinent to what I was looking for.	Strongly agree | ... | Strongly disagree
2.2.3	Overall, I found the results returned by this search system to be relevant to my queries.	Strongly agree | ... | Strongly disagree
2.3 Reliability		
2.3.1	If I were to publish a paper, I would like to be able to confidently cite an item I find through this search engine.	Strongly agree | ... | Strongly disagree
2.3.2	The detail about an item helps me determine if it is reliable.	Strongly agree | ... | Strongly disagree
2.3.3	I could always access the item at the location that the detail about the item pointed to.	Strongly agree | ... | Strongly disagree
2.3.4	Overall, I could easily tell if the information that I obtain from this search engine is reliable.	Strongly agree | ... | Strongly disagree
2.4 Scope of Collection A Digital Library (DL) search engine helps find records that are present in different sources. For instance, AmSouth or ACM would be sources.		
2.4.1	I would prefer to know what sources this search engine uses.	Strongly agree | ... | Strongly disagree
2.4.2	I could use this search engine for a variety of topics.	Strongly agree | ... | Strongly disagree
2.4.3	I feel that this search engine could give me information on many topics in my research.	Strongly agree | ... | Strongly disagree
2.4.4	I would prefer a search engine that has more sources.	Strongly agree | ... | Strongly disagree
2.5 Understandability		
2.5.1	I find the information presented by the search engine to be clear.	Strongly agree | ... | Strongly disagree

2.5.2	When I search for something, I see a page with snippets of information. The information in the snippets is understandable.	Strongly agree | ... | Strongly disagree
2.5.3	The organization of results in different views is clear to me.	Strongly agree | ... | Strongly disagree
2.5.4	I could easily find the usage rights (copyright, print fee etc.) associated with any item.	Strongly agree | ... | Strongly disagree
2.5.5	Overall, I could easily understand the information presented by the search engine.	Strongly agree | ... | Strongly disagree
2.6 Vettedness		
2.6.1	Having each item to be rated, say on a scale of five stars, by an external authority would be helpful for me.	Strongly agree | ... | Strongly disagree
2.7 Openness		
2.7.1	I would prefer to know how different search engines organize results.	Strongly agree | ... | Strongly disagree
2.7.2	The MetaScholar 3D view organizes the search results based on certain attributes (e.g., popularity, collection). It (was/would be) helpful for me to understand the meaning of these attributes.	Strongly agree | ... | Strongly disagree
2.7.3	I would prefer to know how this search engine works so that I can maximize benefits that I could get from it.	Strongly agree | ... | Strongly disagree
	3. System Quality	
3.1 Accessibility		
3.1.1	The homepage of this search engine loads quickly.	Strongly agree | ... | Strongly disagree
3.1.2	This search engine appears to respond quickly on an average.	Strongly agree | ... | Strongly disagree
3.1.3	The text and images associated with the pages of the search engine loads quickly on an average.	Strongly agree | ... | Strongly disagree
3.1.4	Overall, this search engine appears to be responsive.	Strongly agree | ... | Strongly disagree
3.2 Reliability		
3.2.1	The number of times the search engine malfunctioned during my course of interaction was few (less than 3) or none.	Strongly agree | ... | Strongly disagree
3.2.2	Having a logo in the search engine would improve its credibility.	Strongly agree | ... | Strongly disagree

3.2.3	Overall, I feel I would be comfortable to rely on this search engine.	Strongly agree | … | Strongly disagree
3.3 Ease of Use		
3.3.1	Learning to use this search engine was easy.	Strongly agree | … | Strongly disagree
3.3.2	The user interface of this search engine is easily understandable.	Strongly agree | … | Strongly disagree
3.3.3	I found this search engine easy to use.	Strongly agree | … | Strongly disagree
3.3.4	I always felt to be in control of this search engine.	Strongly agree | … | Strongly disagree
3.4 Joy of Use		
3.4.1	I found using this search engine to be fun.	Strongly agree | … | Strongly disagree
3.4.2	I found this search engine to be flexible to my needs.	Strongly agree | … | Strongly disagree
3.4.3	Using this search engine was a pleasant experience.	Strongly agree | ... | Strongly disagree
This search engine works best on Firefox.		
3.4.4	If my favorite browser were not Firefox, I would not use this search engine.	Strongly agree | ... | Strongly disagree
3.5 Freedom of Choice		
3.5.1	I liked the option of having three different views and using what I thought was best.	Strongly agree | ... | Strongly disagree
3.5.2	I would prefer a search engine that offers me different choices and lets me to use what would suit my need.	Strongly agree | ... | Strongly disagree
3.6 Support		
3.6.1	Having some training before using this search engine would have helped me.	Strongly agree | … | Strongly disagree
3.6.2	Availability of instructional help would give me more confidence to use a search engine.	Strongly agree | ... | Strongly disagree
	4. Performance Expectancy	
4.1	Using this search engine could satisfy some of my complicated needs.	Strongly agree | ... | Strongly disagree
4.2	This search engine could be of use in my computer-aided research.	Strongly agree | ... | Strongly disagree
4.3	If I were using CITIDEL or AmSouth, I would use this search engine instead.	Strongly agree | ... | Strongly disagree

4.4	I feel that this search engine can enable find what I want quickly.	Strongly agree | ... | Strongly disagree
4.5	Overall, I found this search engine to be useful.	Strongly agree | ... | Strongly disagree
	5. Social Influence	
5.1	Given what I know, I would use this search engine.	Strongly agree | ... | Strongly disagree
5.2	If my peers encourage using this search engine, I would use it.	Strongly agree | ... | Strongly disagree
5.3	If my superiors encourage using this search engine, I would use it.	Strongly agree | ... | Strongly disagree
5.4	If people who academically influence me encourage using this search engine, I would use it.	Strongly agree | ... | Strongly disagree
	6. Satisfaction	
6.1	I would recommend this search engine to others.	Strongly agree | ... | Strongly disagree
6.2	If I had to login to use this search engine, I would do that.	Strongly agree | ... | Strongly disagree
6.3	Overall, I was satisfied with this search engine.	Strongly agree | ... | Strongly disagree
	7. Intention to use	
7.1	I would use this search engine.	Strongly agree | ... | Strongly disagree
7.2	I plan to use this search engine	Many times a day| … |Never
	8. Information Quality and System Quality	
8.1	This search engine appears to be of good quality in terms of appearance.	Strongly agree | ... | Strongly disagree
8.2	This search engine appears to be of good quality in terms of functioning and the results.	Strongly agree | ... | Strongly disagree

Note:
Three abbreviations in the above questionnaire represent longer expressions, as seen below:
Strongly agree | ... | Strongly disagree:
Strongly agree | Somewhat agree | Slightly agree | Neutral | Slightly disagree | Somewhat disagree | Strongly disagree

Many times a day | … | Never:

Many times a day | Few times a day | Few times a week | Few times a month | Rarely | Never

APPENDIX B

The following tables are the outputs of regression analysis for the model, broken down into smaller parts across different moderating variables, namely: Experience and Voluntariness.

(i) Experience: Graduate Students - Information Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.747990459				
R Square	0.559489726				
Adjusted R Square	0.489408546				
Standard Error	0.958417465				
Observations	52				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	51.33318238	7.333311769	7.983451861	3.09774E-06
Residual	44	40.41681762	0.918564037		
Total	51	91.75			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.440373938	0.506914054	0.868734917	0.389706211	-0.581244194
Relevance	0.414240568	0.136365854	3.037714769	0.003999593	0.139413252
Adequacy	0.062390426	0.117223563	0.532234512	0.59724111	-0.173858139
Understandability	-0.018490723	0.085947322	-0.215140192	0.830652134	-0.191706167
Reliability	0.265439998	0.125234445	2.119544656	0.039722591	0.013046562
Vettedness	-0.053503174	0.104351416	-0.512721115	0.610710971	-0.263809632
Openness	0.150176421	0.110417954	1.360072491	0.180735163	-0.072356339
Scope	0.074138971	0.122830641	0.603586942	0.549217527	-0.173409917

Figure 21: Regression Analysis - Graduate Students - Information Quality

(ii) Experience: Undergraduate Students – Information Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.706464633				
R Square	0.499092277				
Adjusted R Square	0.424488999				
Standard Error	0.954733687				
Observations	55				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	42.6860013	6.098000185	6.689951048	1.65282E-05
Residual	47	42.84127143	0.911516413		
Total	54	85.52727273			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.1296107	0.529902966	0.244593271	0.807836086	-0.936416547
Relevance	0.182389593	0.137718898	1.324361405	0.191787332	-0.094665089
Adequacy	0.170714415	0.123506535	1.382229811	0.173435042	-0.077748682
Understandability	0.130229642	0.110650642	1.176944293	0.245143928	-0.092370734
Reliability	0.438252928	0.152100019	2.881346969	0.005949838	0.132267163
Vettedness	0.001837726	0.119408617	0.015390228	0.987786006	-0.238381423
Openness	0.13293922	0.123384355	1.077439843	0.286782993	-0.115278081
Scope	-0.074498855	0.12213293	-0.609981722	0.544812004	-0.320198615

Figure 22: Regression Analysis - Undergraduate Students – Information Quality

(iii) Experience: Graduate Students – System Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.64978636				
R Square	0.422222314				
Adjusted R Square	0.345185289				
Standard Error	1.325905129				
Observations	52				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	57.81197839	9.635329731	5.480771294	0.000251345
Residual	45	79.11109853	1.758024412		
Total	51	136.9230769			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	1.392795285	0.617011401	2.257325038	0.028888395	0.150070549
Ease of Use	0.086836711	0.144272804	0.601892447	0.550266432	-0.203743628
Joy of Use	0.242484969	0.18948232	1.27972345	0.207201039	-0.139152009
Support	-0.015259304	0.133546871	-0.114261785	0.909538569	-0.284236505
Accessibility	0.360177241	0.159702223	2.255305125	0.029024628	0.038520458
Reliability	0.230412366	0.169054124	1.362950283	0.179679756	-0.110080113
Choice	-0.265473651	0.188165049	-1.410855273	0.165163438	-0.644457509

Figure 23: Regression Analysis - Graduate Students - System Quality

(iv) Experience: Undergraduate Students – System Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.612230449				
R Square	0.374826123				
Adjusted R Square	0.296679388				
Standard Error	1.61073635				
Observations	55				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	74.66536369	12.44422728	4.796439988	0.000662561
Residual	48	124.5346363	2.59447159		
Total	54	199.2			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.376907419	0.952104613	0.395867654	0.693956833	-1.537427174
Ease of Use	0.419663509	0.220746946	1.901106751	0.063300841	-0.024177965
Joy of Use	0.389876734	0.216628008	1.799752203	0.078186696	-0.04568306
Support	0.056528791	0.155725737	0.363002238	0.718196917	-0.256578783
Accessibility	-0.082580815	0.216459403	-0.381507173	0.704510589	-0.517801606
Reliability	0.221355972	0.169352715	1.307070698	0.197415879	-0.119150478
Choice	0.010941969	0.213729632	0.051195374	0.959382296	-0.418790251

Figure 24: Regression Analysis - Undergraduate Students - System Quality

(v) Experience: Graduate Students – Performance Expectancy

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.691172616				
R Square	0.477719585				
Adjusted R Square	0.456402017				
Standard Error	0.964672915				
Observations	52				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	41.70859453	20.85429726	22.40966632	1.22643E-07
Residual	49	45.59909778	0.930593832		
Total	51	87.30769231			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.865622686	0.341004651	2.538448331	0.014362433	0.180348197
Information Quality	0.604349248	0.108151351	5.587995355	1.00266E-06	0.387010975
Social Influence	0.136512337	0.097753032	1.396502334	0.168857339	-0.059929731

Figure 25: Regression Analysis - Graduate Students - Performance Expectancy

(vi) Experience: Undergraduate Students – Performance Expectancy

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.650853294				
R Square	0.423610011				
Adjusted R Square	0.401441165				
Standard Error	1.073675919				
Observations	55				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	44.05544112	22.02772056	19.10834762	6.00658E-07
Residual	52	59.94455888	1.152779979		
Total	54	104			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.721130759	0.400278896	1.80157077	0.077411831	-0.082087591
Information Quality	0.580570418	0.125707616	4.618418809	2.57609E-05	0.328319638
Social Influence	0.24145016	0.11928715	2.024108716	0.048110341	0.002082987

Figure 26: Regression Analysis - Undergraduate Students – Performance Expectancy

(vii) Experience: Graduate Students – Satisfaction

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.794959566				
R Square	0.631960712				
Adjusted R Square	0.6169387				
Standard Error	0.89575535				
Observations	52				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	67.51041838	33.75520919	42.06898002	2.31423E-11
Residual	49	39.3165047	0.802377647		
Total	51	106.8269231			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.010563212	0.342912769	0.030804371	0.975550685	-0.678545785
System Quality	0.387373452	0.08510311	4.5518131	3.5281E-05	0.216352352
Performance Expectancy	0.551489944	0.10657553	5.174639444	4.23877E-06	0.337318401

Figure 27: Regression Analysis - Graduate Students - Satisfaction

(viii) Experience: Undergraduate Students – Satisfaction

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.76235226				
R Square	0.581180968				
Adjusted R Square	0.565072543				
Standard Error	1.001117812				
Observations	55				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	72.32004622	36.16002311	36.07931825	1.48829E-10
Residual	52	52.11631741	1.002236873		
Total	54	124.4363636			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.504655906	0.366746427	1.376034964	0.174708443	-0.231274623
System Quality	0.206529066	0.074675183	2.765698831	0.007844089	0.056682352
Performance Expectancy	0.699098	0.103348527	6.764469876	1.17516E-08	0.491714012

Figure 28: Regression Analysis - Undergraduate Students - Satisfaction

(ix) Experience: Graduate Students – Behavioral Intention

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.796838376				
R Square	0.634951398				
Adjusted R Square	0.627650426				
Standard Error	1.017927511				
Observations	52				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	90.11425604	90.11425604	86.96806307	1.59588E-12
Residual	50	51.80882088	1.036176418		
Total	51	141.9230769			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.336093609	0.322331254	1.04269631	0.302104401	-0.311327755
Satisfaction	0.918451845	0.098486452	9.325666897	1.59588E-12	0.720635989

Figure 29: Regression Analysis - Graduate Students - Behavioral Intention

(x) Experience: Undergraduate Students – Behavioral Intention

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.750529384				
R Square	0.563294356				
Adjusted R Square	0.555054627				
Standard Error	1.212545795				
Observations	55				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	100.5121965	100.5121965	68.3632127	4.18275E-11
Residual	53	77.92416715	1.470267305		
Total	54	178.4363636			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.738749269	0.398711727	1.852840585	0.069476508	-0.060965161
Satisfaction	0.898743425	0.108698736	8.268204926	4.18275E-11	0.680721375

Figure 30: Regression Analysis - Undergraduate Students - Behavioral Intention

(xi) Experience: Voluntary Users – Information Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.759553478				
R Square	0.576921487				
Adjusted R Square	0.524964476				
Standard Error	0.896226045				
Observations	65				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	62.43178057	8.918825796	11.10382376	9.18074E-09
Residual	57	45.78360404	0.803221124		
Total	64	108.2153846			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.23196965	0.381423265	0.608168592	0.545491484	-0.531817258
Relevance	0.36044716	0.114864407	3.138023093	0.002692219	0.130435156
Adequacy	0.117149031	0.102559199	1.142257671	0.258122515	-0.08822222
Understandability	0.004347948	0.076414091	0.056899825	0.954823988	-0.148668629
Reliability	0.285636147	0.120512169	2.370185103	0.02118559	0.044314694
Vettedness	-0.019806946	0.093121669	-0.212699645	0.832320099	-0.206279869
Openness	0.141824273	0.096788121	1.465306609	0.148331912	-0.051990594
Scope	0.053491235	0.125605323	0.425867579	0.671808156	-0.198029084

Figure 31: Regression Analysis - Voluntary Users – Information Quality

(xii) Experience: Involuntary Users – Information Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.643803998				
R Square	0.414483588				
Adjusted R Square	0.290283137				
Standard Error	1.0821427				
Observations	41				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	27.3559168	3.907988115	3.337214837	0.008461075
Residual	33	38.6440832	1.171032824		
Total	40	66			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-0.184739982	0.878503429	-0.210289427	0.834734827	-1.972068639
Relevance	0.309933091	0.189764419	1.633251866	0.11192257	-0.07614552
Adequacy	0.119754114	0.149287632	0.80217036	0.428193628	-0.183973856
Understandability	0.095660525	0.127988905	0.747412631	0.46010748	-0.16473486
Reliability	0.494967857	0.185560623	2.667418605	0.011752523	0.117441934
Vettedness	0.123899042	0.146533508	0.845533858	0.403902101	-0.174225619
Openness	0.026399551	0.150769476	0.175098777	0.862071966	-0.280343253
Scope	-0.016856494	0.137393532	-0.122687681	0.903098569	-0.296385735

Figure 32: Regression Analysis - Involuntary Users
– Information Quality

(xiii) Experience: Voluntary Users – System Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.666061271				
R Square	0.443637617				
Adjusted R Square	0.386082888				
Standard Error	1.289873794				
Observations	65				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	76.94723841	12.82453974	7.708100151	4.10308E-06
Residual	58	96.49891543	1.663774404		
Total	64	173.4461538			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	1.061240379	0.557360428	1.904046871	0.06186869	-0.054437726
Ease of Use	0.18485501	0.133087007	1.388978641	0.170149678	-0.081547576
Joy of Use	0.375374882	0.169082289	2.22007216	0.030336273	0.036919911
Support	-0.102646575	0.118376796	-0.867117367	0.389451033	-0.339603475
Accessibility	0.25054001	0.138113981	1.814009042	0.074849976	-0.025925158
Reliability	0.133774406	0.15499566	0.863084851	0.391645792	-0.176483114
Choice	-0.051414996	0.153775604	-0.334350801	0.739320898	-0.359230309

Figure 33: Regression - Experience - Voluntary Users – System Quality

(xiv) Experience: Involuntary Users – System Quality

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.535534136				
R Square	0.286796811				
Adjusted R Square	0.160937424				
Standard Error	1.773256373				
Observations	41				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	42.99154141	7.165256902	2.278708159	0.059001258
Residual	34	106.9108976	3.144438165		
Total	40	149.902439			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	1.701980637	1.309341844	1.29987493	0.202387814	-0.958922121
Ease of Use	0.21444722	0.280076714	0.765673153	0.449153792	-0.35473714
Joy of Use	0.360905925	0.276827288	1.303722358	0.201086932	-0.201674808
Support	0.063766824	0.186198496	0.342466915	0.734107714	-0.314634044
Accessibility	0.006438225	0.265787665	0.024223191	0.980816192	-0.533707294
Reliability	0.24487969	0.206439095	1.18620792	0.243763572	-0.174655025
Choice	-0.309206924	0.309186145	-1.000067205	0.324342661	-0.937548765

Figure 34: Regression - Experience - Involuntary Users – System Quality

(xv) Experience: Voluntary Users – Performance Expectancy

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.752939525				
R Square	0.566917929				
Adjusted R Square	0.552947539				
Standard Error	0.831520782				
Observations	65				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	56.11615311	28.05807655	40.57996611	5.41597E-12
Residual	62	42.86846228	0.691426811		
Total	64	98.98461538			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.763716804	0.260901829	2.927219046	0.004776429	0.242181484
Information Quality	0.681532332	0.087500865	7.788863918	9.20118E-11	0.506620596
Social Influence	0.080325673	0.083072044	0.966939883	0.337330873	-0.085732976

Figure 35: Regression Analysis - Voluntary Users - Performance Expectancy

(xvi) Experience: Involuntary Users – Performance Expectancy

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.574583031				
R Square	0.33014566				
Adjusted R Square	0.294890168				
Standard Error	1.248591463				
Observations	41				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	29.19776003	14.59888002	9.364375435	0.000493886
Residual	38	59.24126436	1.558980641		
Total	40	88.43902439			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.827726395	0.581285381	1.423958734	0.162618625	-0.349024328
Information Quality	0.479621913	0.159967274	2.998250209	0.004768356	0.1557851
Social Influence	0.317247688	0.146417767	2.16672945	0.036592204	0.020840417

Figure 36: Regression Analysis - Involuntary Users - Performance Expectancy

(xvii) Experience: Voluntary Users – Satisfaction

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.862092852				
R Square	0.743204085				
Adjusted R Square	0.734920346				
Standard Error	0.794093014				
Observations	65				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	113.1499635	56.57498176	89.71843136	4.98002E-19
Residual	62	39.09619033	0.630583715		
Total	64	152.2461538			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-0.391277212	0.26629235	-1.469352055	0.146793529	-0.92358803
System Quality	0.285025964	0.067852644	4.200661134	8.67168E-05	0.149390463
Performance Expectancy	0.842195926	0.089818389	9.376653661	1.68874E-13	0.662651526

Figure 37: Regression Analysis - Voluntary Users - Satisfaction

(xviii) Experience: Involuntary Users – Satisfaction

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.606680238				
R Square	0.368060911				
Adjusted R Square	0.334800959				
Standard Error	1.094979776				
Observations	41				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	26.536294	13.268147	11.06618888	0.000163241
Residual	38	45.56126697	1.19898071		
Total	40	72.09756098			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	1.40378103	0.493468281	2.844723933	0.007121519	0.40480673
System Quality	0.207257588	0.09187974	2.255748536	0.029924664	0.021256781
Performance Expectancy	0.418849225	0.119619542	3.501511697	0.0011999	0.176692125

Figure 38: Regression Analysis - Involuntary Users - Satisfaction

(xix) Experience: Voluntary Users – Behavioral Intention

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.83647277				
R Square	0.699686694				
Adjusted R Square	0.694919816				
Standard Error	0.931277846				
Observations	65				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	127.2999207	127.2999207	146.7809148	4.15786E-18
Residual	63	54.63854082	0.867278426		
Total	64	181.9384615			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.386014551	0.246975599	1.562966351	0.123070219	-0.107526797
Satisfaction	0.914409863	0.075475519	12.11531736	4.15786E-18	0.763584075

Figure 39: Regression - Voluntary Users - Behavioral Intention

(xx) Experience: Involuntary Users – Behavioral Intention

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.648768016				
R Square	0.420899939				
Adjusted R Square	0.406051219				
Standard Error	1.383879566				
Observations	41				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	54.28582626	54.28582626	28.34587443	4.48401E-06
Residual	39	74.68978349	1.915122654		
Total	40	128.9756098			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0.885656292	0.61930835	1.430073231	0.160659093	-0.367013071
Satisfaction	0.867726658	0.162981387	5.324084375	4.48401E-06	0.538065688

Figure 40: Regression - Involuntary Users - Behavioral Intention

APPENDIX C

The following figures show the approval obtained from the IRB at Virginia Tech regarding the user studies as explained.

VirginiaTech

Office of Research Compliance
Institutional Review Board
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4991 **Fax:** 540/231-0959
E-mail: moored@vt.edu
www.irb.vt.edu
FWA00000572(expires 7/20/07)
IRB # is IRB00000667.

DATE: March 28, 2006

MEMORANDUM

TO: Edward A. Fox
Vikram Raj Vidya Sagar

Approval date: 3/27/2006
Continuing Review Due Date:3/12/2007
Expiration Date: 3/26/2007

FROM: David M. Moore

SUBJECT: **IRB Expedited Approval:** "Study of User Quality Metrics for Metasearch Retrieval Ranking" , IRB # 06-192

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective March 27, 2006.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtained re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Important:
If you are conducting **federally funded non-exempt research**, this approval letter must state that the IRB has compared the OSP grant application and IRB application and found the documents to be consistent. Otherwise, this approval letter is invalid for OSP to release funds. Visit our website at http://www.irb.vt.edu/pages/newstudy.htm#OSP for further information.

As indicated on the IRB application, this study is receiving federal funds. The approved IRB application has been compared to the OSP proposal listed above and found to be consistent. Funds involving procedures relating to human subjects may be released. Visit our website at www.irb.vt.edu for further information

cc: File

Figure 41: IRB Approval

VirginiaTech

Office of Research Compliance
Institutional Review Board
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax: 540/231-0959
E-mail: moored@vt.edu
www.irb.vt.edu
FWA00000572(expires 7/20/07)
IRB # is IRB00000667.

DATE: March 30, 2006

MEMORANDUM

TO: Edward A. Fox
Vikram Raj Vidya Sagar

Approval date: 3/27/2006
Continuing Review Due Date:3/12/2007
Expiration Date: 3/26/2007

FROM: David M. Moore

SUBJECT: **IRB Amendment 1 Approval:** "Study of User Quality Metrics for Metasearch Retrieval Ranking" , IRB # 06-192

This memo is regarding the above referenced protocol which was previously granted approval by the IRB on March 27, 2006. You subsequently requested permission to amend your IRB application. Since the requested amendment is nonsubstantive in nature, I, as Chair of the Virginia Tech Institutional Review Board, have granted approval for requested protocol amendment, effective as of March 29, 2006. The anniversary date will remain the same as the original approval date.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtained re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

As indicated on the IRB application, this study is receiving federal funds. The approved IRB application has been compared to the OSP proposal listed above and found to be consistent. Funds involving procedures relating to human subjects may be released. Visit our website at www.irb.vt.edu for further information

cc: File

Figure 42: IRB Amendment Approval

APPENDIX D

The following e-mails show the correspondence with authors of papers from which images were reproduced in this thesis.

Delete Reply Reply All Forward Redirect View Source Move to: This message to

Date: Thu, 18 Jan 2007 08:04:56 -0800
From: Marcos Andre Goncalves <mgoncalv@dcc.ufmg.br>
To: Vikram Raj <vikki@vt.edu>
Subject: Re: Permission to use a figure from your paper

This message was written in a character set other than your own. If it is not displayed correctly, click h

Sure.

Vikram Raj wrote:
> Hello Dr. Gonçalves,
> I am working on my thesis, which is related to digital library success models.
> I found your paper "What is a good Digital Library?" – A Quality Model for
> Digital Libraries" interesting. I find the figure illustrating the life cycle
> of a digital object to be closely related to what I am working on. Can I have
> your permission to reproduce this figure in my thesis?
>
> Thanks,
> Vikram
>

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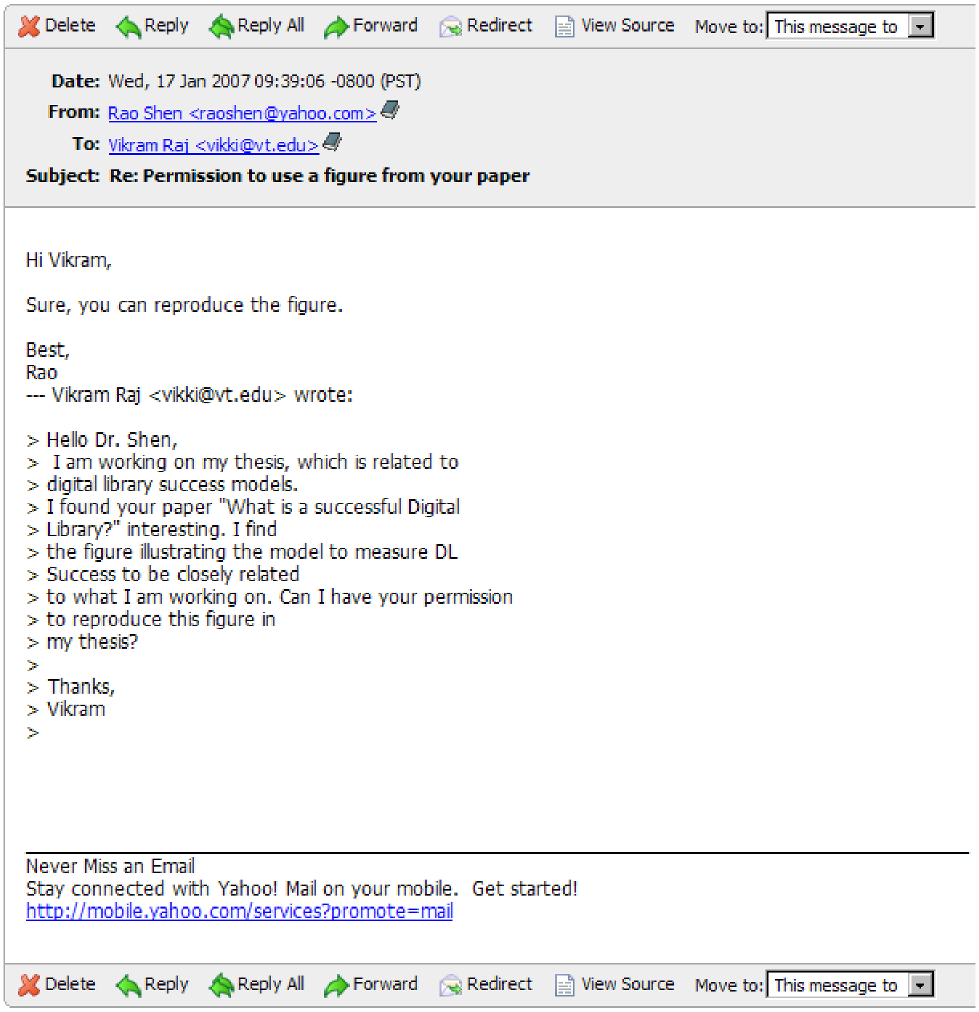
Figure 43: Permission obtained from Dr. Gonçalves to reproduce Figure 18


Delete Reply Reply All Forward Redirect View Source Move to: This message to

Date: Wed, 17 Jan 2007 09:39:06 -0800 (PST)
From: Rao Shen <raoshen@yahoo.com>
To: Vikram Raj <vikki@vt.edu>
Subject: **Re: Permission to use a figure from your paper**

Hi Vikram,

Sure, you can reproduce the figure.

Best,
Rao
--- Vikram Raj <vikki@vt.edu> wrote:

> Hello Dr. Shen,
> I am working on my thesis, which is related to
> digital library success models.
> I found your paper "What is a successful Digital
> Library?" interesting. I find
> the figure illustrating the model to measure DL
> Success to be closely related
> to what I am working on. Can I have your permission
> to reproduce this figure in
> my thesis?
>
> Thanks,
> Vikram
>

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http://mobile.yahoo.com/services?promote=mail

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Figure 44: Permission obtained from Dr. Shen to reproduce Figure 19