The Effect of Interface Design on E-Commerce Web Sites for Product Information Learning and Search Performance

by

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Abstract

The e-commerce environment is emerging as a critical factor in a firm's success. Different web interface designs may determine whether firms keep or lose their customers. Web site design should allow customers to navigate and search product information naturally and with minimal cognitive effort. This study will suggest a cognitive process model of human users in transacting with the web site interface; it also will examine the effect of information search guidance in a web site on the understanding of the product and the acceptance of the Web information system. Declarative knowledge and production knowledge of a unified cognitive learning model will be investigated to explain how information is gained through web site navigation. Information search guidance in a web site will be objective web site characteristics (i.e., breadth and depth of hypertext structure), as well as subjectively perceived evaluation of the web site interface design. The current study also will investigate the effect of Web navigation experience on a user's attitudes and beliefs (i.e., self-efficacy, task support satisfaction, and interface satisfaction). The result of Partial Least Square (PLS) and Multivariate Analysis of Variance (MANOVA) analyses shows that declarative knowledge of the product is not significantly related to antecedent variables of web site interface attributes, nor to the dependent variables. Procedural knowledge, however, presents strong associations with interface design and web site system satisfaction and self-efficacy. Discussion about the results and conclusions is provided.

Chapter 1. Introduction

The e-commerce environment is dramatically changing the traditional marketplace and is emerging as a critical factor in a firm's success. Different Web interface designs may determine whether firms keep or lose their customers. For instance, Hoffman et al. (1996) assert that e-commerce web sites should allow customers to feel "flow" during navigation. They emphasize that web site design should allow customers to navigate naturally with minimal cognitive effort. More research on the implications of interface design in electronic commerce web sites is needed.

Customers usually visit a Web site (Web store) to buy electronic products, such as digital camera, computer, or TV sets without full knowledge of the product's functions or a sense of the alternatives. Customers search product information via the Web store before actually purchasing a product. The more accurate the information on the web site, the higher the probability that customers will complete a purchase (Smith et al. 1997). There is a high possibility of purchase, not only when the customer realizes the Web site provides complete product information, but also when the customer is satisfied with the assistance the site provides in incorporating that information. If a customer is dissatisfied with the quality or quantity of the information about the product on one site, he or she will go to another site and probably buy a product elsewhere. The sooner the customer locates the right information and product, the more often he or she decides to buy the product on the spot.

The shortcoming of research on Web navigation is its lack of a theoretical framework. People often are lost while navigating web sites (Kim et al. 2004; Otter et al. 2000; Spence 1999; Te'eni et al. 2003). Hypertext structure plays a crucial role in keeping visitors to a site from getting lost. Hypertext refers to a collection of documents containing cross-references or "links" which, with the aid of an interactive browser program, allow the reader to move easily from one document to another. The information in the hypertext needs to support the users' information search (Gay et al. 1991; King et al. 1990; Mohageg 1992; Utting et al. 1989). It is generally agreed that currently we have poor theoretical and research perspectives from which to understand special characteristics associated with learning in hypertext systems (Jacobson et al. 1995; Tergan 1997). Researchers of human cognition can offer established methodologies and conceptual frameworks to investigate the cognitive processes involved in the use of electronic environments, such as the Web (Boechler 2001). The internal mental model is involved when people browse, model, interpret, and formulate a browsing strategy (Spence 1999). In the field of human/computer interface research, governmental organizations, technology firms, and academia have developed several usability guidelines. From a research perspective, however, they lack a systematic psychological framework to guide and structure the assessment and reporting activities of systems (Andre et al. 2001).

As Alavi et al. (2001) note, there is very little research in the information systems field on the internal psychological processes through which learning occurs. They stress that the research question should advance from "Does technology influence learning?" to "How can technology enhance learning?" thereby asserting that without affecting these processes, it is impossible to affect learning outcomes. Many cognitive theories have been put forth to explain the information search-and-navigation mechanism in web sites; examples include the Lewin Experimental Learning Model (Lewin 1951), Kolb's

Learning Model (Kolb 1984), and the schema theory (Lawless et al. 1997). There is no integrated theoretical model, however, to explain the underlying cognitive interaction between human beings and web site interface.

This study will suggest a cognitive process model of human users in transacting with the web site interface, and will examine the effect of information and search guidance in a web site on the understanding of the product and the acceptance of the Web information system.

The research questions examined in the present study are:

- How can a theoretical model of cognitive process help one understand a product information search?
- How can one design a web site that will enhance the cognitive learning process during a product information search?
- Will an enhanced learning process influence self-efficacy, interface satisfaction, and task support satisfaction in the context of a product information search?

The literature background, research model and hypotheses, methodology to evaluate the hypotheses, results of data analysis, and contribution of findings, will be discussed in the following chapters.

Chapter 2. Literature Review

Comparison of a graphical user interface (GUI) and the command-based DOS environment was heavily researched in the 1980s and 1990s. Presently, the Windows computing environment is dominant, and comparisons among GUIs are needed. Moreover, the interface embeds rich content in the amount and type of information (Olfman et al. 1994a). The GUI environment provides large amounts of information. As a result, traditional training methods are not necessarily appropriate for GUI (Olfman, 1994). Therefore we should take an additional step to determine the aspects of GUI that influence the individual dimension of human performance. The result will aid designers to learn how to manipulate the interface factors to enhance user performance.

The importance of interface design also is emphasized in marketing research. The e-commerce environment is changing the traditional marketplace dramatically, and it is emerging as a critical factor in a firm's success. Marketing research (Hoffman et al. 1996) on e-commerce incorporates the "flow" concept in the human navigation behavior in web sites. It emphasizes the role of web site design that allows customers to navigate naturally with minimal cognitive barriers. The interface components that enhance declarative and procedural knowledge of products also increase users' flow in the web sites.

2.1. Cognitive mechanism as an explanation of interface design

Over the past two decades, human/computer interaction (HCI) has progressively integrated its scientific concerns with the engineering goal of improving the usability of computer systems and applications, thus establishing a body of technical knowledge and methodology (Carroll 1997). HCI continues to provide a challenging test domain for applying and developing psychology and social science in the context of technology development and use.

We can view the Web as an environment with a cognitive component (hyperspace) and a social component (cyberspace) (Boechler 2001). This review argues that cognitive psychologists have a key role in the identification and analysis of ways that the processes of the mind interact with the Web. The body of literature on cognitive processes provides us with knowledge about spatial perceptions, strategies for navigation in cyberspace, memory functions and limitations, and the formation of mental representations of environments. Researchers of human cognition can offer established methodologies and a conceptual framework toward investigation of the cognitions involved in the use of electronic environments, such as the Web.

A study by Scaife et al. (1996) outlines some of the central properties of a relationship that applies to cognitive science. It also considers how this analysis can improve the selection and design of both traditional and advanced forms of graphical technology.

A model by Kitajima et al. (1995) provides a principled explanation of action slips—errors made by experienced users. The model is based on Hutchins, Holland, and

Norman's (1986) analysis of direct manipulation and is implemented using Kintsch and Mannes's (1991) construction/integration theory of action planning. The model attends to a limited number of objects on the screen, and then selects action on one of them, such as moving a mouse cursor, clicking a mouse button, typing letters, and so on, by integrating information from various sources. These sources include the display, task goals, expected display states, and knowledge about the interface and the application domain. The model simulates a graph drawing task. In addition, it describes how the model makes errors, even when it is provided with sufficient knowledge to generate correct actions.

2.2. Procedural information in Graphic User Interface (GUI)

Several studies claim there exists some procedural information in Graphic User Interface (GUI) and, hence, the conceptual information-based training content and method will be more effective than that of procedural information, contrary to the fact that command-based computing needs more procedural-oriented instruction (Olfman et al. 1994a). The empirical results, however, show no superior effect of a conceptual information provision in GUI training (Olfman et al. 1994a). Possible explanations for this are: (1) GUI does not embed some procedural information, and/or (2) conceptual information is not enough to infer GUI procedures. GUI may not be designed properly to embed the procedural knowledge, even if it was originally invented to provide procedures for task implementation. One can design an efficient GUI by manipulating aspects that help embed procedural knowledge. To solve the second probable proposition, the training needs to provide procedural information as well as conceptual information.

Bieber et al. (1997) present a set of high-level hypermedia features, including typed nodes and links, link attributes, structure-based queries, transclusions, warm and hot links, private and public links, hypermedia access permissions, computed personalized links, external link databases, link update mechanisms, overviews, trails, guided tours, backtracking, and history-based navigation. They have their discussion on the hypermedia research literature and illustrate each feature, both from existing implementations and a running scenario. They also give some direction for implementing these on the World Wide Web (WWW) and in other information systems.

A study compares way-finding of real world with that of virtual worlds (Darken et al. 1996). In a complex searching task in a number of virtual worlds with differing environmental cues, each condition has a radial grid, a map, or both a grid and a map. The control condition provides no additional navigation cues. The map condition that results is superior to the control and grid condition. The grid, however, is shown to provide superior directional information, as compared to the other conditions. If there are no navigational cues, subjects experience disorientation and extreme difficulty completing the task.

A usability analysis by Cockburn et al. (1996) identifies inadequacies in the clients' interfaces. Motivated by the analysis of usability problems, they propose extensions to the design of WWW client applications. These proposals are demonstrated by their system, WebNet, which uses dynamic graphical overview diagrams to extend the navigational facilities of conventional World Wide Web client applications.

2.3. Human-Computer Interface (HCI) in electronic commerce

The emerging electronic market has enormous impact on the modern economy. Customers or buyers can access sellers through the Internet, and the environment offers what amounts to free competition. Different Web interface designs may determine whether sellers will keep or lose the customers. Several studies apply the previous usability evaluation framework to an electronic commerce web site design to try to predict the success of the site. More research, however, on the specificity of an electronic commerce business web site, compared to intra-organizational information systems, is needed. This study fills the gap by applying an accepted cognitive model to the electronic business environment to evaluate a Web site's success.

The existing marketing research does not discuss the impact of hypermedia of a computer-based environment, such as the Internet, on marketing theory and business practice (Hoffman et al., 1996). Despite the explosive holiday purchases in the electronic stores, and the belief that the Web will play a phenomenal role in marketing strategy in the near future, there is rare academic effort to understand the effect of hypermedia web-based business circumstances on the transition of marketing (Hoffman et al., 1996). Recently, marketing researchers are paying more academic attention to the electronic commerce environment. Taylor (2000) brought several critical research questions that should be addressed in the marketing field: more study of the behavior of Internet users and their motivations for either purchasing over the Internet or being responsive to advertising over the Internet; research on factors related to the success of on-line ads and measures of Internet ad effectiveness; and how organizations use the Internet to communicate both internally and externally. Taylor (2000), however, claimed that keeping up with rapid advances in technology will be a challenge for marketing researchers for years to come. This research will assist marketing researchers in designing a web-based commercial store to entice more customers to make purchases, and in preparing advertisements on the Internet to attract customers.

A paper by Miles et al. (2000) briefly introduces the electronic commerce task from the perspective of the buyer, and then reviews and analyzes the technologies. A framework is then proposed to describe the design dimensions of electronic commerce. They illustrate how this framework may be used to generate additional hypothetical technologies that may be worth further exploration.

A study by Tauscher et al. (1997) compared different history mechanisms and found that the stack-based prediction method prevalent in commercial browsers is inferior to the simpler approach of showing the last few recently visited URLs, with duplicates removed. Based on empirical evidence, eight design guidelines for Web browser history mechanisms were then formulated.

In a study by Ng (2003), the results of a literature review of environment-behavior research on shopping and shopping environments (e.g., farmer's markets, shopping centers, and electronic shopping) are presented. The focus of analysis is on how the physical features (e.g., layout and background music) influence shoppers' experiences, and how well these environments satisfy the psychological needs of their shoppers (e.g., social interaction, sensory stimulation, and security and comfort). Implications for environmental design and the future of shopping environments are discussed. A conceptual framework and suggestions for future research are proposed.

2.4. Methods of usability evaluation

A study by Vaughan (1998) drew from human/computer interaction, as well as cognitive psychology. The following principles were implemented and tested: maximizing use of the users' expectations and stereotypes, and minimizing the users' memory load. Nine interfaces were created using Hypercard's datebook program. On each interface, the graphics and text were manipulated according to the design principle and the related cognitive psychology research.

Observational data analysis is frequently the only appropriate empirical approach. Diverse approaches to observational data analysis already exist, which are synthesized as instances of exploratory sequential data analysis (ESDA). In a paper by Sanderson et al. (1994b), they outline fundamental ESDA characteristics that might help HCI investigators using sequential data make better conceptual and methodological choices. They also introduce the "Eight Cs"—different general transformations that can be performed on sequential data. They conjecture that the Eight Cs, and their combinations, are critical to support scientific inferences in ESDA. Distinctions are made among three principal ESDA traditions that are relevant for HCI—behavioral, cognitive, and social. We indicate how each ESDA tradition has been used in HCI and describe one technique from each tradition. Then they outline major practical problems for investigators using observational data and, following their framework, suggest ways such problems might be overcome.

Sanderson et al. (1994b) also describe the utility of process models to summarize the sequential actions of individuals. Such models describe why users did what they did, what information they used from the outside environment, and what knowledge they used to perform the task. These detailed explanations of users' thoughts and actions can enhance interface design by offering behavior summaries that can be inspected and transferred to new interfaces. Sequential data sets and models for human/computer interaction often are large and complex. They present a computer-supported methodology to develop these models as summaries of sequential data. Then Ritter et al. (1994)

illustrate that this methodology can make building and using such models tractable by applying it to an existing model for using an online database.

Statistical and grammatical techniques are reviewed as an integrated approach to exploratory sequential data analysis (ESDA) for categorical data by Olson et al. (1994). The first step is identification and validation of the categories to be analyzed. The main statistical techniques discussed are log-linear modeling and lag sequential analysis. These methods allow for statistical evaluation of a wide range of general and specific hypotheses about sequential structure. Grammatical techniques based on definite-clause grammars are described and illustrated, and the complex issue of measuring the "good fit" of a set of patterns is discussed. Throughout the article, examples from their own research illustrate how the various techniques are used, especially in concert, while carrying out ESDA. Several other human/computer interaction and computer-supported cooperative work applications of these techniques are discussed.

A paper by Sanderson et al. (1994a) discusses some of the problems associated with observational data analysis for complex domains and introduces the term exploratory sequential data analysis (ESDA) to describe the different kinds of observational data analysis currently performed in many areas of the behavioral and social sciences. The development and functionality of a software tool—MacSHAPA—for certain kinds of ESDA is described. MacSHAPA is designed to bring investigators into closer contact with their data and to help them achieve greater research productivity and quality. MacSHAPA allows investigators to see their data in various ways: to enter it, edit it, and encode it; and to carry out statistical analyses and make reports.

Gray (1998) contends that an interest in the design of experiments, different from an interest in the design of interfaces, has not been a core topic for researchers and practitioners in the field of human-computer interaction (HCI). He asserts that, to the extent that reliable and valid guidance for the human-computer interaction depends on the results of the former, it is necessary that researchers and practitioners understand how small features of an experimental design can cast large shadows over the results and conclusions. In his review, he examines the design of five experiments that compare usability evaluation methods (UEMs). Making such choices based on misleading or erroneous user evaluation methods can compromise the quality and integrity of the evaluation, incur unnecessary costs, or undermine the practitioner's credibility within the design team.

Lohse et al. (1998) look at the relationship between sales and user interface design, arguing that now more than ever, the promise of electronic commerce and online shopping will depend, to a great extent, on the interface and how people interact with the computer. From the rationale that limited menus, poorly designed navigation, and the difficulty of comparing multiple products on the same screen, all have adverse effects on electronic shopping. They reviewed online retail store attributes, such as the number of links into the store, image sizes, number of products, and store navigation features, hoping that the process of designing and evaluating alternative storefronts will be facilitated by identifying key features that impact traffic and sales.

Sears (1997) describes a new technique that combines the benefits of heuristic evaluations, cognitive walkthroughs, and usability walkthroughs: heuristic walkthroughs, which are more thorough than cognitive walkthroughs and more valid than heuristic evaluations. That is, heuristic walkthroughs result in finding more problems than cognitive walkthroughs and fewer false positives than heuristic evaluations.

Kim (1999) also asserts that designing effective navigation aids for customer interfaces is critical for the success of cyber shopping malls. He classifies navigation aids into either basic ones, which are based on the structure of the malls, or add-ons, which are not. He presents an empirical study that investigates the navigation process of customers and the subjective evaluation of their shopping experience in two metaphor conditions, one based on a spatial metaphor and the other on a non-spatial metaphor. The results indicate that navigation aids based on the spatial metaphor are used more frequently, resulting in better understanding of the entire structure of the cyber shopping malls, which in turn leads to an increased ease of finding target items, and also a more pleasant shopping experience. The benefits of navigation aids based on the spatial metaphor become more evident when customers look for ad hoc category items, rather than common items.

In sum, if one learns a task and operation via exploration of the targeting system, the GUI might be designed to provide conceptual and procedural information at the same time. As a result, the exploration will help him or her learn and perform the task and operation well. In addition, the GUI should be refined to properly embed procedural information.

Therefore, this study attempts to resolve the following issues:

- What GUI components that are related to the proper procedural information and conceptual information;

- The impact of the GUI components on procedural and conceptual cognitive learning process; and
- The relationship among procedural and conceptual cognitive learning processes (enhanced by the GUI support) and interface satisfaction, task support satisfaction, self-efficacy, and performance.

Chapter 3. Research Model

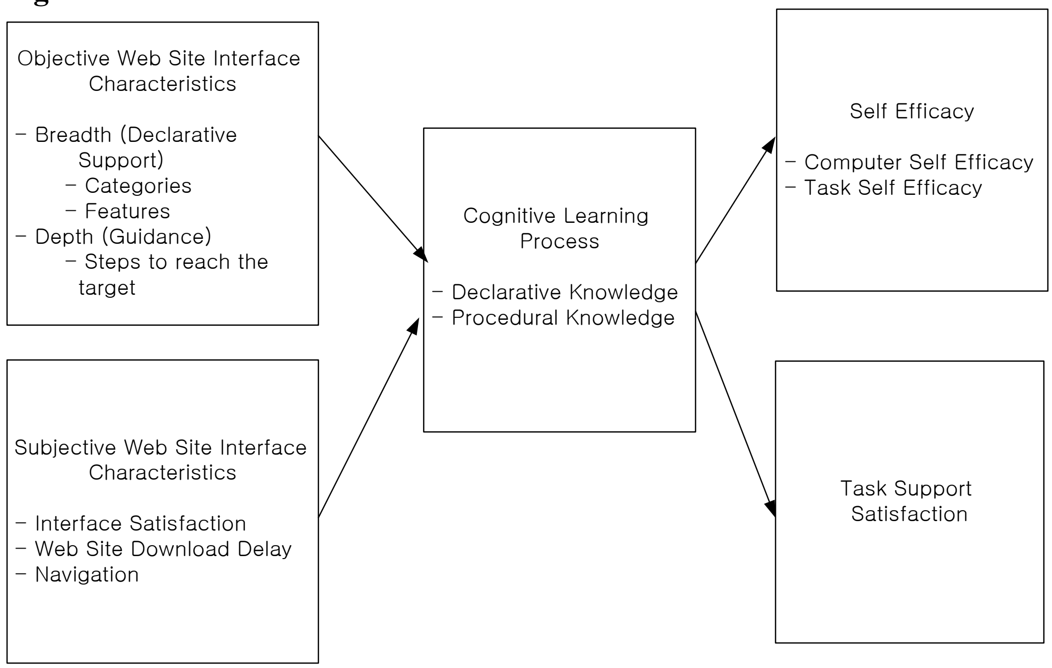
This study investigates the relationship among web site usability, web site design components, cognitive learning processes, self-efficacy, interface satisfaction, and task support satisfaction. The research model is introduced in figure 3-1 and the constructs will be explained in detail.

3.1. Cognitive learning process

Learning models are important in learning environment design (Piccoli et al. 2001). Learning consists of the development of abstract models to represent reality (O.Loughlin 1992). Objectivists and constructivists claim different approaches for learning models (Jonassen 1993). Both models of learning apply to the design of the learning environment, including learning management information systems. It is important to continue the research that explicitly acknowledges the role of the learning model and in which the researcher either must control it or evaluate its effects (Leidner et al. 1995). Failure to do so leads to an inability to compare different learning environments, contributing to a proliferation of inconsistent research results (Leidner et al. 1995).

In searching product information on a web site, those learning models also can be applied, as the learning processes of knowledge acquisition, retrieval, and encoding also occur during Web navigation. It appears that the cognitive model of the learning process is the most appropriate activity in information search on web sites, because an individual performs it without collaboration with others. The product search task is one of the most frequent tasks performed on web sites, and it is mostly accomplished alone. The cognitive learning model represents the way an individual processes information.

Figure 3-1 Research Model



One can explain how information is gained through web site navigation by means of a unified cognitive learning model, such as ACT-R (Anderson 1982a; Anderson et al. 1998). ACT-R is a cognitive architecture: a theory for simulating and understanding human cognition. Learning is directly related to the product information search and leads to knowledge acquisition, knowledge retrieval, and knowledge encoding (Byrne 2001b; Salvucci 2001). Two basic components of ACT-R involve the development of declarative knowledge structures and production knowledge structures:

"ACT-R is a production system theory that tries to explain human cognition by developing a model of the knowledge structures that underlie cognition. There are two types of knowledge representation in ACT-R—declarative and procedural knowledge. Declarative knowledge corresponds to things we are aware we know and can usually describe to others, for example, "George Washington was the first president" and "An atom is like the solar system." Procedural knowledge is knowledge that we display in our behavior, but are not conscious of. For instance, no one can describe the rules by which we speak a language and yet we do. In ACT-R, declarative knowledge is represented in structures called chunks, whereas procedural knowledge is represented in productions. Thus chunks and productions are the basic building blocks for an ACT-R model (ACT/R_Research_Group 2003)."

The learning stages of ACT-R have been extensively studied and validated (Ackerman 1988a; Anderson 1982b; Charney et al. 1987a; Fitts et al. 1967a; Hiebert et al. 1986a; Kraiger et al. 1993a; Olfman et al. 1994b; Schneider et al. 1977a; Shiffrin et al. 1977a). Despite the varying terminology, the underlying processes at each skill-acquisition phase are similar (Anderson 1982a; 1983).

3.1.1. Declarative and procedural knowledge

The procedural stage is known to follow the declarative stage in skill acquisition (Rumelhart 1978). In the declarative stage, one may reproduce a behavior only through a heavy reliance on declarative knowledge (chunks) contained in working memory (Weiss 1990). Accordingly, performance is slow and the trainees' ability to attend to task-irrelevant information or to react to novel task-relevant stimuli is low (Kraiger et al. 1993b).

The production stage in skill acquisition involves the transition from knowledge that is declarative to knowledge that is procedural. The transition is called production compilation. The compilation process compresses two production rules that apply in succession into a single rule by moving knowledge that is stored declaratively into a procedural form. People can implement a task faster and error-free without retrieving chunks embedded in production rules. This is the ultimate goal of production learning

(ACT/R_Research_Group 2003; Anderson 1982a; Anderson et al. 2002; Fitts et al. 1967b; Neves et al. 1981).

Olfman (1994b) also defines two kinds of content when one trains—concepts, which are fact-based, and procedures, which are task-based. Similar definitions of the kinds of knowledge are provided in his study shown in Table 3–1. They focus on procedural and conceptual knowledge.

Kraiger et al. (1993b) also claim the role of production compilation. They developed a classification scheme to evaluate learning outcomes into cognitive (verbal knowledge, knowledge organization, and cognitive strategies), skill-based (compilation and automaticity), and affective learning outcomes (attitudinal and motivational). Cognitive outcomes refer to declarative knowledge that addresses what the facts and concepts of the task are (Anderson 1982a). This is the most well-known learning outcome in information systems (IS) research, as well as in the education field. A study built an example of conceptual and procedural knowledge in computer use (Simon et al. 1996).

Table 3-1 Definitions of Training-Related Knowledge excerpted from (Olfman et al. 1994b)

	Conceptual		Procedural	
Author(s)	**Term**	**Definition**	**Term**	**Definition**
Anderson (1982)	Declarative	Knowledge of facts	Procedural	Knowledge of how to do things
Kieras & Poison (1985)	How-it-works	A hierarchy of concept explanations	How-to-do-it	Knowledge of various tasks
Hiebert & Lefevre (1987)	Conceptual	Knowledge of relationships between pieces of information	Procedural	A formal language and rules for completing tasks
Charney & Reder (1987)	Conceptual + Usage	Knowing what procedures exist and circumstances for applying procedures	Procedural	Knowing how to carry out procedures

Ackerman (1988b) presents converging delineations of fundamental characteristics of skill acquisition that have been offered over the last few decades. Fitts and Posner (1967b) suggest that from a cognitive information-processing perspective, skill acquisition can be segmented into three phases: cognitive (Phase 1), associative (Phase 2), and autonomous (Phase 3). More recent production system models of learning term these phases (1) declarative stage, (2) knowledge compilation, and (3) procedural stage. In a more empirical framework Schneider et al. (1977b) and Shiffrin et al. (1977b), they are labeled (1) controlled processing, (2) mixed controlled and automatic processing, and (3) automatic processing. Despite the varying terminology, the underlying processes at each skill-acquisition phase are qualitatively identical and, by and large, quantitatively identical to the aforementioned approaches (Anderson 1982a; 1983).

Initial confrontation with a skill-acquisition task (assuming that the information-processing requirements are relatively novel) involves a strong demand on the cognitive—the attentional system. During this phase, performance is slow and error-prone, as strategies (productions) are formulated and tested, and attention is primarily given to understanding and performing the task in question. With consistent practice (as described by Schneider and Shiffrin (1977b)), performance speed and accuracy increase markedly, and attentional demands are reduced (Fisk et al. 1983). The productions needed to accurately perform the task are fully formulated. During this second stage (Phase 2), the stimulus/response connections of the skill are refined and strengthened. Ultimately, the final stage of performance is best characterized as autonomous or automatic (Phase 3). Consistent practice results in fast and accurate performance; the task often can be completed competently, even when attention is simultaneously devoted to other tasks (e.g., Schneider and Fisk, 1982). Practice at this stage yields diminishing returns, in keeping with the power law of practice (Newell 1981).

The human memory system has two long-term memory stores: a declarative memory and a procedural memory. Taatgen (1999) introduced an outline of the general skill-learning model. The four types of knowledge that comprise the task-specific knowledge each have a different representation. Among those representations, declarative rules are those that are stored as facts. The counterpart to declarative rules is procedural rules.

Acquired and learned knowledge are stored in the long-term memory in the form of productions that went through composition and proceduralization (Taatgen 1999). Proceduralization integrates declarative knowledge into production rules, and the composition collapses several sequential productions into one (Anderson et al. 2002). Each time a declarative rule is used, therefore, there is a small probability it will be compiled into a production rule. Although both representations (before and after the proceduralization) will lead to the same results, there are differences. The declarative rule cannot act by itself. It needs to be interpreted by production rules. The procedural representation can do this in a single step, so it is much faster.

Another mechanism of long-term learning is storing knowledge in the form of "instance." Instead of using a rule to solve a problem, an example or instance can be retrieved that immediately contains the answer, in a fashion that is comparable to Logan's (1988) instance theory. Similarly in ACT-R, achieved goals are kept in declarative memory automatically and serve as instances that can be retrieved later. Storing knowledge in the form of compiled production and instances is efficient, in that retrieving an instance or using a production rule is generally the fastest strategy, followed by using a declarative rule.

In the perspective of knowledge management, declarative knowledge is approximate to explicit knowledge, and procedural knowledge to tacit knowledge (Nonaka, 1994). Knowledge creation is one of crucial organizational process. Individuals in an organization play important roles in knowledge creation. Explicit and tacit knowledge are two dimensions of the organizational process. Explicit knowledge is conceptually analogous to declarative knowledge in that it refers to knowledge that is transmittable in formal and systematic language. Tacit knowledge is similar to procedural knowledge in that it cannot be codified easily by language, but is expressed in activity and skills. The difference is that the former concepts from Anderson's theory form such unidirectional relationships that a body of knowledge is created only if declarative knowledge is created first and integrated into procedural knowledge. On the contrary, explicit and tacit knowledge are modeled to have bidirectional relationships in the knowledge management field.

3.1.2. Interaction between procedural knowledge and declarative knowledge

3.1.2.1. Effect of declarative knowledge on procedural knowledge

We all have experienced situations where we would not have remembered what the lecturer taught in the class if we had not written down the facts and relationships during the lecture. Even though we felt we totally understood what the lecturer said at the time, the knowledge obtained quickly fades. This clearly exemplifies the reality that procedural knowledge cannot be solely stored in the long-term memory without the construction of declarative knowledge. This is particularly true when one learns new or unfamiliar knowledge. The gained procedural knowledge draws on the already-built declarative knowledge stored in one's long-term memory before it is polished during production compilation and proceduralization. This explains how practice accelerates learning. The activation rate of the declarative knowledge requested by the production increases and, further, the declarative knowledge is proceduralized into the production rule so that it saves time for the declarative retrieval from the long-term memory.

Linking declarative (conceptual) and procedural knowledge has mutual benefits (Hiebert et al. 1986b). Declarative knowledge helps procedural knowledge by developing meaning for symbols, recalling procedures, and effectively using procedures. There are several reasons to believe that connecting procedures with their conceptual underpinnings is the key to producing procedures that are stored and retrieved more successfully. First, procedures become stored as part of a network of information, glued together with semantic relationships; second, retrieval is enhanced because the network of the knowledge structure enables one to access the procedure. There are three ways to facilitate the effective use of procedures: Conceptual knowledge can (1) enhance problem representations and simplify procedural demands; (2) monitor procedure selection and execution; and (3) promote transfer and reduce the number of procedures required.

Conceptual instruction leads to increased conceptual understanding and to generation and transfer of a correct procedure (Rittle-Johnson et al. 1999). Procedural instruction leads to increased conceptual understanding and to adoption of the instructed procedure. These findings highlight the causal relations between conceptual and procedural knowledge and suggest that conceptual knowledge may have a greater influence on procedural knowledge than the reverse.

3.1.2.2. Effect of procedural knowledge on declarative knowledge

Pprocedural knowledge facilitates declarative knowledge using two mechanisms. First, automated and efficient procedures make room to apply conceptual knowledge. Procedures apply concepts to solve problems by converting initially conceptual knowledge to knowledge that is procedural (Anderson 1982a). Conceptual (declarative) knowledge is gradually transformed into set routines (condition/action pairs) to solve the problems. In addition, the application of conceptual knowledge is facilitated, as highly routinized procedures can reduce the mental effort required to solve a problem and thereby make possible the solution of complex tasks (Hiebert et al. 1986b). That is, efficient procedures require less of one's limited cognitive processing capacity (Case

1985); hence, this frees additional space for more effortful processes (Kotovsky et al. 1985).

The second advantage of applying procedure to concepts is that procedures promote concepts (Hiebert et al. 1986b). New procedures can trigger the development of concepts for individuals. It appears that, on occasion, procedural knowledge takes the lead and spurs the development of new concepts. Baroody (1984) presents some instances in which young children's conceptual development is motivated by the application of procedures. Another study shows that the instruction, which encourages students to develop their own procedures and to make sense of procedures presented by others, appears to facilitate higher levels of understanding and closer connections between understanding and skill (Hiebert et al. 1996).

The cognitive load theory suggests that some instructional procedures require learners to engage in cognitive activities solely because of the manner in which information is presented, rather than because of the intrinsic characteristics of the material. The efficacy of equations or words may depend, in part, on their cognitive load consequences. Leung et al.'s (1997) experiments on the cognitive load consequences of learning from equations, rather than words, validates the belief that an equation format involving simple equations and familiar notations is more effective than an equivalent verbal format, which requires substantial reading. Another experiment shows that when the use of notations becomes automated after extended practice, thus reducing the extraneous cognitive load required to mentally integrate notations and meanings, an equation format can be more effective than a verbal format. This again confirms that production compilation frees the short-term memory capacity and allows other functions to use that room.

Conceptual and procedural knowledge develop in an iterative fashion, and the increasing amount of support for correct problem representation facilitates the relationship and, hence, leads to gains in procedural knowledge. In experiments conducted with 5th- and 6th-grade students learning about decimal fractions, the children's initial conceptual knowledge predicted gains in procedural knowledge, and gains in procedural knowledge predicted improvements in conceptual knowledge (Rittle-Johnson et al. 2001).

3.1.3. The role of experience

There is much empirical evidence on the role of experience in the information search task on the Web. For instance, knowledge acquisition of text is assumed to be a process of building a mental model of the specific subject (Lippitsch 2003). For readers with more prior knowledge, the building of an accurate mental model is easier because they do not have to establish a new structure. Readers with less or no prior knowledge might build an inadequate mental model of a subject. In a hypertext learning environment, this could be prevented by several adaptive features that offer the user additional information. The effectiveness and efficiency of such adaptive features within an online course were examined by assessing the users' acquired domain knowledge, the users' satisfaction, and achievement of the users' objectives.

One example of graphic navigational aids is integrated into hypertext to reduce disorientation and cognitive overload during hypertext learning (Moller et al. 2000). Research shows, however, that navigational aids do not automatically lead to better understanding or improved memory achievement. Moller's (2000) study reveals an interaction effect of a navigational aid and prior knowledge: Availability of a navigational aid promotes a stronger improvement in the knowledge level for students with low prior knowledge, compared to students with high prior knowledge.

3.2. The role of interface on learning

Michael Kanellos, senior department editor of CNET News.com, wrote of the important role of Web navigation design while introducing IBM's research emphasis on the fact that IBM is combining anthropology, game theory, and behavioral economics with technologies from its labs to see if it can make corporate processes run smoother:

"Corporations are notorious for introducing technology without considering the human consequences. Eric Johnson, a professor at the Columbia Business School, has found that maximizing "stickiness"—or increasing the time a customer spends on a Web site—is actually a bad goal for e-commerce companies to pursue. Stickiness usually connotes that customers are getting lost on a Web site. By contrast, Amazon.com has seen revenue rise and stickiness decline, because easy navigation brings customers back (CNET News.com)".

Information systems play a critical role in transferring knowledge to and among human workers. The abundant information and the efficient way to present the information of IS can be better utilized than traditional training to help users to learn a new task.

Learning a system and the task implemented through the system is, then, divided into the initial declarative stage and later production compilation stage. If the system interface is designed to support both stages, with appropriate mechanisms derived from the cumulated learning theories, users can implement tasks through the system without extra effort in training. First, we assess the relationship of the declarative activation stage and procedural compilation stage in learning the product information of a web site. The next sections will discuss critical factors enhancing (or prohibiting) learning in each stage and suggest interface elements that can manipulate those factors.

"…This is further evidence that the effect may be an interface effect and not reflect any real proficiency in coding…" (Anderson et al. 1989).

Studies of the ACT-R model have investigated only the fit to real human responses (Taatgen et al. 2003). That is, they explored the cognitive components and processes in learning. This study, however, finds the ecological factors that affect the cognitive learning processes and hence, speeds up learning and improves the attitude toward information systems.

Song (2002) emphasizes the role of individual differences in the hypertext learning environment to provide information helpful in designing interactive hypermedia; ten studies are divided into five categories, according to current significant research groups in the hypermedia field.

Jacobson (2000) proposes an approach for developing a hypermedia case and problem-centered knowledge resources—the knowledge mediator framework (KMF)—

which consists of design elements and learning activities that have specific socio-cognitive theoretical and research rationales, hoping that the framework and research outlined in this article may contribute to design and pedagogical principles for hypermedia learning tools that help students construct a rich and useful understanding of challenging knowledge. His study involves high school students using a hypermedia system, based on the main features of the KMF, to learn neo-Darwinian evolutionary biology. Students using the experimental hypermedia system were found to change their evolutionary biology problem-solving models and to continue to use expert-like models even one year after using the system.

Beishuizen (1996) claims that the potential advantages of hypertext may be better utilized in closed-search tasks, in which an answer to a particular question has to be found. Because hypertext puts heavier cognitive demands on the student, the quality of the learning style of the student is crucial to success. He found that both deep-processing students and surface-processing students are able to find a requested text unit in a hypertext unit in a hypertext database, provided their regulation style matched their processing style. That is, deep-processing students should act on the basis of internal control, whereas surface-processing students should seek external guidance. The availability of local navigation facilities (such as text links or facilities for full-text search) contributes to the usability of hypertext, in particular for those users who prefer a surface-processing style. Because surface-processing students are vulnerable to losing track, however, they need external guidance to support their search attempts.

3.2.1. Declarative retrieval

When students learn a skill, especially in the early stage of learning, they need declarative (explicit) knowledge of the task. The need for the declarative knowledge disappears, while the knowledge is embedded in the reduced production rules (production compilation). The declarative knowledge needed in the early stage of learning is temporarily buffered in the short-term memory retrieved from long-term memory. The activated (retrieved) declarative knowledge is interpreted from the general production rule, which also is stored in the long-term memory.

The web site navigation for information search might help the early stage of declarative knowledge (product knowledge) activation by alleviating the short-term memory workload. The appropriate declarative information of the product necessary to process production rules can be provided and listed by means of hyperlink labels, a unique advantage of web site interface. Instead of searching the declarative knowledge of the product stored in the long-term memory of the user, the features labeled on the hyperlinks in the web site will be used to obtain the needed declarative knowledge of the product to process general production rules in the early stage of learning the task (e.g., product information search before the actual purchasing).

Declarative information on the product is encoded in the long-term memory network (Anderson et al. 1984). The early ACT (Atomic Component of Thought) theories assumed that the declarative information on the product necessary for the production rule was already built into human memory. The external stimulus activates only one chunk, with the highest probability among all the related chunks in a slot of the production rule.

When there is little knowledge encoded previously in the long-term memory, one uses learning strategies already previously tried. As there is no initial task-specific knowledge, except for some uninterpreted instructions and possible biases, general "commonsense" knowledge is needed to make a start. This knowledge is indicated by the term *learning strategies* (Taatgen 1999). Learning strategies interpret instructions or try to modify declarative rules for other, similar tasks, or use other strategies to come up with methods to do the new task. Using a learning strategy is generally only a good idea if the existing knowledge is insufficient or incorrect.

3.2.2. Production compilation

Another beneficial function of hyperlinks is that they can replace the task-specific production rules that one should implement to complete a task. This, again, lightens the load of a procedural buffer (Anderson et al. 2002), which temporarily stores the retrieved procedural knowledge from the procedural long-term memory. When one learns new phenomena, s/he goes through production compilation using the mechanisms of composition and proceduralization. If one can accomplish a task only by following the navigation interface, s/he does not need to spend time and effort scanning the memory to find the most appropriate production rule that operates the initial declarative knowledge.

Directional information is embedded in the production rules. Anderson and Fincham (1994) discovered an asymmetry in applying knowledge in the practiced direction versus the reverse direction: People are faster in the practiced direction than the non-practiced direction, but only for the procedural task. They explain that the directional and procedural knowledge is embedded in the production rule; in contrast, declarative knowledge is stored in chunks that can be assessed equally well in either direction. This highlights the importance of navigation guidance. If a web site is well designed to consistently provide the correct direction to reach the target information, people rapidly will learn the embedded information with less effort.

An examination of the function of the presentation format of interface on conceptual learning was implemented: Maple's (a computer algebra system) symbolic computation, graphic display, and animation capabilities support an integrated set of procedures for active study of sampling distributions and concepts related to samples, populations, and statistical decision-making, error, and power (Snyder 1995).

Another consideration in using a declarative rule is that it uses working-memory capacity (Taatgen 1999). The function normally attributed to working memory—keeping track of currently relevant task knowledge—is related to the spread of activation from the goal. Due to the interpretation process of the declarative rule, the activation that originates from the goal has a larger fan: It is spread out over more chunks and becomes thinner. In terms of working-memory capacity, the declarative rule consumes some of the working-memory capacity that is available for normal processing.

Production compilation refers to the process occurring during the transformation of declarative knowledge into procedural knowledge (Anderson et al., 1998). For instance, in order to learn to ride a bicycle the declarative knowledge of turning the handle left or right in order to avoid falling to the ground should be transformed into the actual riding of a bicycle without falling down. In the current study, declarative and procedural knowledge are considered to be acquired in an ordered time frame and we call the process of transformation from declarative to procedural knowledge as production compilation.

3.2.3. Long-term memory encoding

In addition to the initial stage of learning, there is the ultimate stage of learning—storing the learned declarative and procedural knowledge of the product in the long-term memory. The latest stage of learning is the production rule tuning, and it comprises three mechanisms: generalization, discrimination, and strengthening. Through these processes, one completes learning a task.

In order to see if one stores learned information in long-term memory, one must check if the knowledge can be transferred into the same kind of (but reasonably different) task from the tried tasks in the learning period. Procedural knowledge is not stored in long-term memory (Kitajima et al. 1992). The conceptual knowledge facilitated by the procedural information, however, definitely will be stored in long-term memory and will contribute to the fact that one can perform another similar type of task with the obtained knowledge.

In sum, the Web navigation design can facilitate learning by three means: the list of initial declarative knowledge of the product necessary to learn and complete the task; the guidance of the routes to complete the task; and the web site usability guidelines that directly influence generalization, discrimination, and strengthening.

3.3. The effect of breadth and depth of Web design characteristics on declarative and procedural knowledge on the product

A GOMS analysis (Card et al. 1983)f an information search task in different web sites shows that the number of categories and features (breadth), and the number of steps to reach the target information (depth), determines the learning and execution time of users. In the current study, breadth and depth of information presentation structure will be varied in order to examine the effect of objective Web design characteristics on the cognitive learning process of information.

GOMS is a family of techniques for modeling and describing human task performance. GOMS stands for Goals, Operators, Methods, and Selection Rules, the components of which are used as the building blocks for a GOMS model. Goals represent the goals that a user is trying to accomplish, usually specified in a hierarchical manner. Operators are the set of atomic-level operations with which a user composes a solution to a goal. Methods represent sequences of operators, grouped together to accomplish a single goal. Selection Rules are used to decide which method to use for solving a goal when several are applicable.

There are depth/breadth tradeoffs in the information search on the Web (Zaphiris 1997). While increased depth does harm search performance on the Web, a medium condition of depth and breadth outperforms the broadest, shallowest Web structure overall (Larson et al. 1998). The depth/breadth tradeoffs affect the menu design and user performance in the GUI-based applications (Kiger 1984; Lee 1985; Miller 1981; Norman 1991; Perkinson et al. 1985), including Web information systems. In Jacko et.al's (1996) experiment, as depth increased, perceived complexity of the menus increased significantly,. He suggests that the cognitive component influencing users' perceptions of task complexity was short-term memory load. When breadth increases along with depth, the short-term memory load is reduced, as users do not need to memorize all the steps in the depth, but they do need to choose and click the appropriate node among the presented alternatives.

The number of categories and features of product information represents “breadth.” “Categories” are the independent dimensions of the product (e.g., brand, pixel, memory, zoom, etc.), and “features” are sub-lists that belong to each category (e.g., Sony, Canon, Philips, etc.) under the category of brand. The categories and features are the declarative knowledge about the product (e.g., digital camera) in that they represent static and factual information about the product (Anderson 1982a). In addition, they comprise the nodes of the web site that customers should click in order to reach the target product (e.g., digital camera).

Web design can facilitate users’ selective attention, thus allowing them to learn effectively (Leidner et al. 1995). Given learners’ limited information processing capacity, attention is selective (Bovy 1981). Selective attention is an interrelated function of the display, the cognitive structure of the learner, and the prior experience of the learner. Pre-instructional methods, such as topic outlines and learning goals, might improve learning because they direct attention (Bruning 1983).

3.3.1. *Effect of categories and features on declarative knowledge activation of product (short-term memory)*

In the production system, chunks in goal and retrieval buffers should be activated first. After the chunks of both buffers are matched (rule test, left-hand side), the action (right-hand side) can update or change the chunks. As the activation is faster and more accurate, the production system can be effectively executed, and chunks will not be retrieved anymore; hence, production compilation will occur. The activation of chunks is influenced by base-rate knowledge (experience or expertise) and the associated strength between the current chunk and other chunks in the working memory with the following relationship (ACT/R_Research_Group 2003).

$$A_i = B_i + \sum_j W_j S_{ji}$$

The activation of a chunk i

Where the summation is over the elements j in the goal, B_i is the base-level activation of the chunk *i*, S_{ji}'s are the measures of the strengths of association between the elements j and i, and W_j reflects the weighting given to the jth element. ACT-R 5.0 tutorial (2003) provides details about the formula.

The declarative knowledge (chunks j) of the product in the task of searching a product in a B2C web site may be the categories and features of the products, and i is the corresponding feature of the product. As the number of the information is greater, the amount of chunks (j) utilized in the production system of the task to search the product is expected to be greater. As a result, S_{ji} and W_j values will be smaller if we assume the weights and association among chunks are all the same; hence, A_i will be smaller. Several experimental studies have confirmed the relationship. There is empirical evidence that people succeed in locating a specified target among options in the menu in a graphic-user interface when the number of options is smaller (Byrne 2001a; Nilsen 1991). As the number of items in the menu is greater, the time spent to find the target and click also is greater. Based on the above we hypothesize:

H1a. As the number of categories and features of a product increases (high level of breadth), the declarative knowledge activation of the product will decrease.

3.3.2. Effect of depth on production compilation

In a business-to-consumer (B2C) product search, a procedural aspect of a task might be how one navigates and locates the product for which he is looking. If an interface is well designed to guide a customer to reach his or her goal, the production compilation will take place faster and more accurately; hence, the job is better implemented.

There can be multiple productions that match the buffers' current contents; thus, the issue arises of selecting which production to fire. Each production has a utility associated with it, which reflects how much the production is expected to contribute to achieving the model's current objective (ACT/R_Research_Group 2003). The utility of a production *i* is defined as: where P_i is the expected probability that production i firing will lead to a successful completion of the current objective, C_i is the expected cost of achieving that objective, and G is the value of the objective. An appropriate guidance of an interface will decrease C_i and increase P_i.

$$U_i = P_iG - C_i$$

The utility of a production i

Therefore, the hypothesis is:

H1b. As an interface guides the customer to locate the product with greater depth, customers reach production compilation more effectively.

3.3.3. Effect of breadth on long-term declarative knowledge of the product (long-term memory)

As the number of categories and features listed on a web site increases, the product detail is much better defined. When the product information is disseminated as finely as possible, and people are provided with all possible information about the product, they can understand the product more completely than when the categories and features are loosely listed. The amount of information (i.e., categories and features) will not help retrieval from short-term memory, but may influence long-term memory. When information is abundant, there are more chances to explore the characteristics of a product, which will help people understand more about it. Some empirical evidence has shown the elaboration of instructions on how to acquire knowledge helps people learn and remember the main ideas from a text. A product information search on a web site is equivalent to a product information search in an offline product catalogue. A rich list of categories of the product on a web site will help customers find the target product and information, just as elaboration of information does in a text material. Category information about a product listed on a commercial web site will play a similar role of elaboration in learning. With a large amount of information, people can come to appreciate the differences among the dimensions of products, which stimulates them to store those regenerated pieces of information in their long-term memory (Anderson et al. 1998). Applications of the role of elaboration on knowledge acquisition (Charney et al. 1987b) to web site navigation have been done in several studies (Fu et al. 2002; Kim 1999; McDonald et al. 1999; Padovani et al. 2003; Shneiderman 1997; Zimmerman et al. 2000). Therefore:

H1c. As breadth increases, long-term declarative knowledge of the product also increases.

3.4. Web usability guidelines related to information learning

In addition to the objective web site characteristics (i.e., depth and breadth), subjective Web usability evaluation also can predict a successful information search and user satisfaction. The International Organization for Standardization (ISO) defines usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use (ISO9241-11 1998). While this definition originated for interfaces between a general system and a human, it also can apply to the interface between an electronic commerce web site and customers, in that a web site system is a type of information system. Objective interface characteristics (e.g., input/output media, dialogue type, language characteristics [help facility, error diagnostics, default options, abbreviation options], presentation format [tabular graphical]) of web site usability were investigated in a study (Benbasat et al. 1981). Another study shows that users of a direct-manipulation interface and a menu-based interface did not differ in the total amount of time used to perform a task (Lim et al. 1996). Other studies also indicate usability is related to several positive outcomes, such as reduction in the number of errors, enhanced accuracy, a more positive attitude toward the target system, and increased usage (Lecerof et al. 1998; Nielsen 2003).

Nielsen (1994) derives seven usability issues that explain actual usability problems of information systems by employing a factor analysis of 294 usability heuristics extracted from seven projects. The projects include studies of Molich and Nielsen (1990), Star user interface (Carroll et al. 1992; Holcomb et al. 1989; Polson et al. 1990; Smith 1982), Macintosh Human Interface Guidelines (AppleComputer 1992), and SunSoft usability guidelines (Rohn 1993). The exhaustive list of interface usability tests was given to users to rate web sites in order to examine the effect of deconstructed interface design components on the cognitive process of learning information. "Visibility of system status," "match between system and real world," and "recognition rather than recall" are presumed to have an effect on the declarative knowledge of a product. "User control and freedom," "consistency and standards," and "flexibility and efficiency of use" are supposed to influence procedural knowledge. Only items of an above-50 percent load in each factor were chosen.

Research is lacking on the effect of usability evaluation criteria on users in terms of their behaviors in navigating web sites, learning information, and targeting the product they want. The main studies on Web usability evaluation are still concentrated on finding dimensions of usability testing (Lavie et al. 2004; Nielsen 1994) and evaluating method framework (Andre et al. 2001; Hartson et al. 2001). The type of Web usability includes assistance in locating information using task-relevant terminology (Smith et al. 1997), information quality of web site (Lin et al. 2000), amount and variety of product information (Jahng et al. 2000; Palmer 2002), and variety of presentation of product information (Kim et al. 2002). Web usability evaluations may be studied as antecedents that influence information learning on web sites. Some Web usability may affect users in learning declarative knowledge regarding products, while other usability may influence the learning of procedural knowledge in the way users find their target product on a web site.

Among other existing usability measures are those addressing factors that have a potential to affect the information search process and perceived success of the Web system. The measures hypothesized to have an effect on declarative knowledge of product are interface satisfaction (H2a), while those for procedural knowledge are interface satisfaction (H2b) (Garrity et al. 1998b), web site download delay (H2c), and navigation (H2d) (Palmer 2002). Garrity and Sanders' (1998b) measure of interface satisfaction draws on the consideration of the interface as a component in the human machine subsystem. They claim an inappropriate interface can lead to extra workload and negative impact the user's environment. In addition they assert interface satisfaction can influence decision-making support. In the context of learning information on web sites, interface satisfaction is hypothesized to affect two types of information learned, i.e., declarative and procedural knowledge of the product, as a proxy for web site usability; hence, interface satisfaction may be mediated to impact decision-making support by the two types of knowledge. Therefore, the hypotheses for the effect of interface satisfaction on declarative and procedural knowledge of product are:

H2a: Interface satisfaction will enhance declarative knowledge of a product.

H2b: Interface satisfaction will enhance procedural knowledge of a product.

Web site download delay and navigation effectiveness are among critical web site usability factors to which customers sensitively respond (Palmer 2002). Excluding the effect of Internet line speed, the infrastructure of a web site can be designed to provide the requested information to customers as promptly as possible. The longer customers have to wait for a response, the higher the probability they will leave the web site and never return. In the context of learning information on web sites, customers are presumed to be closely associated with procedural knowledge acquisition in that it will help them rapidly find out how to locate a product, as well as information regarding it. The related hypotheses are:

H2c: Web site download delay will be related negatively to procedural knowledge.

H2d: Navigation effectiveness will be related positively to procedural knowledge.

3.5. Self-efficacy and task support satisfaction

The enhanced cognitive learning process also may influence Web information acceptance, computer self-efficacy (confidence in computer ability by user), task self-efficacy (confidence in task ability by user), and task support satisfaction. Computer experience has been found to be associated with self-efficacy, perceived ease of use, and perceived usefulness (Compeau et al. 1995; Davis 1989; Hill et al. 1987; Marakas et al. 1998). Gist et al. (1992) discovered computer experience is likely to improve a person's perceptions and beliefs about using the technology by increasing his or her belief in the ability to master the challenge while reducing any fears. Hill et al. (Hill et al. 1987) found experience has an indirect effect on computer usage through self-efficacy, perceived ease of use, and perceived usefulness.

In this study, interface satisfaction and task support satisfaction will replace ease of use and usefulness, respectively. Garrity and Sanders (1998b) integrated existing information systems' success measures in discriminate constructs. Among those constructs, ease of use was loaded to interface satisfaction, and usefulness was loaded to task support satisfaction. The above research results may apply to the two constructs to a greater extent in that they include a larger set of success measures accepted in information systems fields. Interface satisfaction is hypothesized to be an antecedent variable that has an effect on two types of knowledge learning, and task support satisfaction is hypothesized to be influenced by the two knowledge acquisitions in the model.

Therefore, the current study will investigate the effect of Web navigation experience on a user's attitudes and beliefs (i.e., self-efficacy and task support satisfaction).

3.5.1. Self-efficacy and learning performance

Self-efficacy plays a crucial role in information systems learning and use (Nahl 1996). Some studies place self-efficacy as an antecedent variable to ease of use (Igbaria et al. 1995; Venkatesh 2000; Venkatesh et al. 1996; Yi et al. 2003b), and some studies put ease of use as an antecedent to self-efficacy (Henry et al. 1994). For example, there are individuals who consider computers too complex. They believe they never will be able to control computers and prefer to avoid using them. Individuals with high self-efficacy will perceive the system as simple and useful, due to the effect of self-efficacy on the degree of effort related to learning that takes place (Bandura 1977).

Gist et al. (1992) suggest that the perceived difficulty of performing a task (low ease of use) may mediate the relationship between self-efficacy and performance, and they found that self-efficacy affects perceived ease of use but not perceived usefulness. This might be because the researchers did not distinguish between computer self-efficacy and task self-efficacy. Perceived usefulness is an outcome judgment, according to Bandura (1977). If one implements a task successfully with a system, one will use the system more frequently through enhanced task self-efficacy; that is, perceived usefulness will be directly affected by task self-efficacy.

Marakas et al. (1998) provide a thorough review of the extant literature related to Computer Self-Efficacy (CSE). It presents an integrated model of empirical findings and a conceptual model of CSE, and proposes guidelines of both measurement and manipulation of the construct.

Task characteristics, such as perceived difficulty, novelty, ambiguity, or complexity, can have a direct effect on the formation of perceptions of self-efficacy (SE). Campbell (1988) and Wood (1986) found that the number of component parts involved in completing a task, and the sequential steps required to perform it successfully, have direct effects on the formation of SE perceptions. Cervone (1985) demonstrated that when subjects are asked to focus on the more formidable aspects of a task, their self-efficacy is lowered.

Task ambiguities (e.g., inaccurate or ambiguous feedback, ill-defined performance levels, or external factors) indirectly affect CSE through their influence on internal variables (e.g., behavioral and psychological strategies, personality traits, or mood). In this case, the estimations of SE are not translated into appropriate levels of effort (Marakas et al. 1998).

Similarly, myriad computer training experiences cannot relate to a clear understanding of the relevance of a particular skill as well as the nature of the expected task outcome relates to such skill acquisition; the subject may form relatively high estimations of CSE that are not translatable into any meaningful levels of performance (Marakas et al. 1998).

The SE measure should embrace task-specific context, cross-domain skills, and levels of analysis (Marakas et al. 1998). If the task performance measure is specific in nature, the questions must be constructed so that the subject is focused only on his or her ability within that specific task context, if any interpretable results are to be obtained.

CSE can be manipulated to be enhanced. Gist and Mitchell (1992) argue, however, that any or all of several distinct factors can serve to influence the degree of any change in CSE. These are level effect, variability, locus, and controllability.

There is a strong call for more research on CSE as a dependent variable. It is evidenced by CSE appearing twelve times as an independent variable and twenty-two times as a dependent variable (Marakas et al. 1998). This observation suggests that research to date has been more interested in those factors that can influence changes in CSE, rather than CSE as either a moderator or an antecedent variable. One plausible reason for this is that CSE is strongly related to actual performance. This suggests that discovering antecedents to CSE will have a high possibility of inducing better performance.

In this study, computer-specific (or task-specific) self-efficacy might be task difficulty (complexity or novelty), perceived effort, and assigned goals or anchoring, which are included in the multifaceted model of specific computer self-efficacy (Marakas et al. 1998).

There is general self-efficacy and task-specific self-efficacy. General self-efficacy is measured in pre-training; specific SE is measured in post-training (Agarwal et al. 2000).

3.5.1.1. Learning Performance, Computer Self-Efficacy, and Task Self-Efficacy

Participants low in self-efficacy report greater confidence in their ability to master the software training in the modeling, as compared with the tutorial conditions (Piccoli et al. 2001). Participants in the modeling training report more effective cognitive working styles, more ease with the task, more satisfaction with the training, and less frustration, as compared with participants in tutorial training.

Yi et al. (2003a) assert self-efficacy as a mediator in the relationship between the learning process and performance outcome. Observational learning processes are represented as a second-order construct with four dimensions: attention, retention, production, and motivation. New measures for these dimensions were developed and shown to have strong psychometric properties. The proposed model controls two pre-training individual differences (motivation to learn and self-efficacy) and specifies the relationships among three training outcomes: declarative knowledge of product, post-training self-efficacy, and task performance.

Eyring et al. (1993) draw on a recent multiple-stage model developed by Ackerman (1989, 1990) that posits that the individual-difference factors influencing performance vary, depending on the skill acquisition stage. They examined the effect of ability on early skill acquisition, and results revealed that ability, self-efficacy, and familiarity predict the learning-rate constant, whereas self-efficacy predicts asymptotic performance.

Torkzadeh (2002) reports on the effects of training on Internet self-efficacy and computer-user attitudes. Survey responses were collected at both the beginning and end of an introductory computer course. Respondents with high and low attitudes toward computers seem to benefit equally from training programs. Respondents with a positive attitude toward computers, however, have higher self-efficacy scores than respondents with a negative attitude toward computers. Training programs do not seem to influence attitudes toward computer usage for males or females.

Many studies indicate that self-efficacy is an antecedent of learning performance. Lee et al. (2002) found that self-efficacy has significant effects on learning, but in negative directions. Furthermore, the relative impact of self-efficacy on learning changes over time, as expected, and the positive effects of self-efficacy in the early stages of training remain at later stages of training.

Chen et al. (2000a) tested a model of relationships among trait-like individual differences (cognitive ability, general self-efficacy, and goal orientation), state-like individual differences (state anxiety, task-specific self-efficacy, and goals), and learning performance in two field studies in an academic setting. They found that state-like individual differences mediate the relationships between trait-like individual differences and learning performance.

A study by Bell et al. (2002) reveals that learning orientation is related positively to self-efficacy, performance, and knowledge, whereas performance orientation is related negatively to performance only.

- Task Self-Efficacy

Self-efficacy is the extent to which one perceives he or she is good at a skill or a domain (Bandura 1991). Self-efficacy can be categorized as general self-efficacy and task-specific self-efficacy (Chen et al. 2000b). Task-specific self-efficacy represents an individual's intention to allocate mental or physical effort to achieve a targeted level of performance (Kanfer 1987). In the current study, computer self-efficacy is a self-efficacy related to computer skill; another self-efficacy related to information system use is task self-efficacy. IS research has considered computer self-efficacy as an instrument to measure competence of computer skill (Compeau et al. 1995). Information systems, however, have their own goal tasks to be achieved. One could have self-efficacy for the task domain independent of that for the computer.

From the perspective of learning, computer and task self-efficacy are affective learning outcomes (Kraiger et al. 1993b). Individuals revise their self-efficacy as training progresses (Martocchio et al. 1997). While individuals initially form self-efficacy beliefs about a novel task, relying on an analysis of task requirements, personal factors, and situational factors, they are likely to revise their self-efficacy beliefs on the basis of an attributional analysis as they begin gaining experience with the task (Gist et al. 1992). That is, if one can learn information about a task and the procedure to complete it, one will have high self-efficacy about the information systems and task at the same time.

Generally, learning occurs when facts are stored in the long-term memory, and they are retrieved in the future. That is, we may expect that long-term memory storage of facts (i.e., declarative knowledge of product) learned during task performance will increase the affective learning outcome, task self-efficacy. Hence,

H3a. An increase in declarative knowledge of the product acquired during task performance will increase the affective learning outcome, task self-efficacy.

- Product Search and Self-Efficacy

You follow the procedures of an interface to complete a task. When you repeat the task many times, you can do it nearly automatically. This we call "production compilation." As you become good at the procedures, you are confident not only with the task but also with the computer use. That is, while you compile the production you will have more computer self-efficacy (Compeau et al. 1995).

Self-efficacy is influenced by previous experience. If one succeeds in the antecedent representative work and has enactive mastery of the corresponding task, one has a high level of self-efficacy (Bandura 1977; Wood et al. 1989). When the effort and persistence used during the task is perceived above the threshold, however, self-efficacy is negatively influenced (Bandura et al. 1983). In the same rationale, computer self-efficacy also will be influenced by the previous use of the actual system (Delcourt et al. 1993; Garrity 2001; Kinzie et al. 1994; Miura 1987; Ogletree et al. 1990). If one must use too much effort to finish a job using an information system, computer self-efficacy will decrease.

While one navigates a web site to find a product, the lower endeavor in the success of the job will raise computer self-efficacy, as well as task self-efficacy. The effort made during the product search is reduced by fast completion and will enhance computer self-efficacy, as introduced in Figure 3-2. Hence,

H3b. Fast compilation will enhance computer self-efficacy.

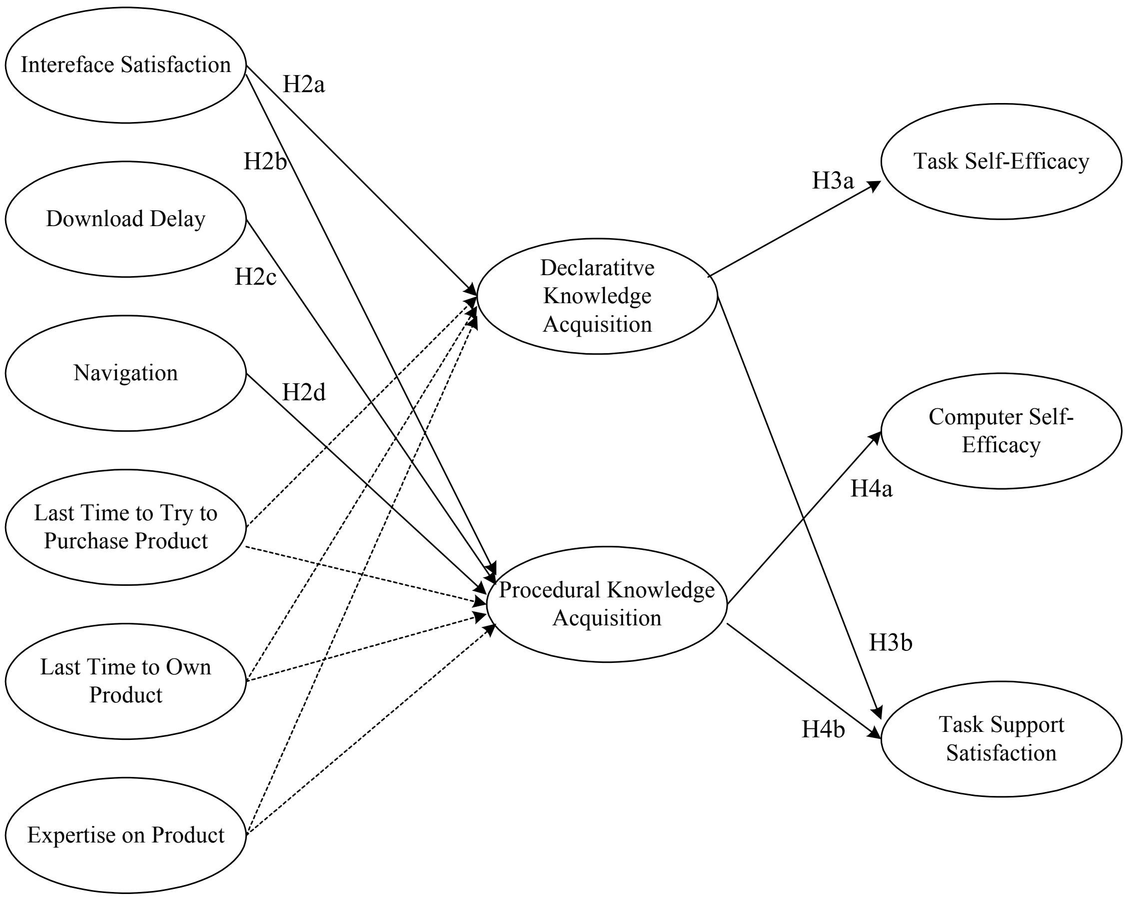
3.6. Task Support Satisfaction

Enhanced declarative and procedural knowledge of the product will affect task support satisfaction. The task support satisfaction dimension is concerned with the fit among the system, the user, and the task (Garrity et al. 1998a). As information systems are designed and implemented within, between, and across organizational boundaries, the implementation and use of IS can have a profound impact on a worker's ability to accomplish the tasks necessary to achieve the goals of the larger organizational system (Garrity 2001; Sherman et al. 2002). Systems that are sound and robust in technical terms still may be deemed failures if designers do not pay close attention to achieving a close fit with the task requirements of users, and gain a thorough understanding of how users actually accomplish work.

A well-designed web site will allow customers the satisfactory experience of searching or purchasing the product or services. It will lead them to succeed in finding the most appropriate product and complete the purchase without difficulty; hence, they will perceive that the web site supports their task satisfactorily. This may result from the role of declarative and procedural knowledge of the product achieved during the web site navigation. Hence, *H4a. Enhanced long-term declarative knowledge of the product will cause one to perceive the Web information system as supporting tasks.*

H4b. Enhanced task self-efficacy will positively affect task support satisfaction.

Figure 3-2 Hypothesized Research Model



Note. Constructs with dotted arrow are control variables.

Chapter 4. Experimental Method

4.1. Business-to-Customer (B2C) sites comparison (quasi-treatments)

B2C sites selling digital cameras were chosen for testing the hypotheses. The sites vary in the number of categories and features. The digital camera has many characteristics, such as pixels, monitors, and brands. Each site has a categorization of the characteristics, and each category has many features. For instance, a category of pixels has features of 3, 5, or 10 mega-pixels. The number of categories was counted and used as the value of the variable throughout the sites. Sites that had both larger and smaller numbers of categories were chosen; this resulted in four sites.

Subjects in the experiment were asked about base-rate learning (that is, previous experience with purchasing products or searching for information about products in B2C sites); the number of products purchased; and the number of times searching product information from the chosen B2C sites and from other B2C sites during previous months. Those who bought a digital camera recently (i.e., within one month) were eliminated. Perceived web site usability was asked of subjects after they finished their tasks. They also were requested to rate their base-rate experience with B2C sites and the Internet.

The instructions led subjects to pay attention only to the menus categorizing the features of the products. If there were alternative ways to reach the goal product, they were asked to consider a menu specified in the instruction. Therefore, each site has only one menu interface for the subjects to follow.

Subjects were chosen from among undergraduates majoring in business administration. The effect of the number of categories and guidance was a between-subject setting, and other effects were a within-subject setting. As partial least squares (PLS) analysis requires a certain number of subjects, 50 subjects were selected for each site, according to the current model. As a whole, 200 subjects were employed. Operationalization of interface category (breadth) and guidance (breadth) are introduced in Table 4-1 and web sites chosen for this experiment are listed in Table 4-2.

4.2. Procedure

Four web sites were chosen, all of which sell digital cameras. They vary in the number of categories and features (breadth) and the number of steps (depth) to reach the target digital camera (Figure 4-1, 4-2).

Subjects were given the remote experiment (i.e., different place and different time with the experimenter). The Keynote eXpress research tool (http://www.keynote.com/solutions/cem_rt_express.html) was employed to implement the remote data collection. It allowed collection of Internet navigation log data and analyzed it. Subjects were asked to search for two digital cameras in a web site. Student subjects recruited in an introductory course of information system were given the written instruction on how they should navigate in the given websites. They were asked to start the navigation only from the category menu placed in a certain position in a given website. Each subject only navigated the give website given in one of the four different type of questionnaire packet. Therefore there occurred four groups of subjects who were given a website among the four different websites. When they start the experiment they downloaded the Keynote eXpress plug-in to their internet explorer. The plug-in recorded

Table 4-1 Operationalization of interface attribute

Manipulation	Level	Definitions
Depth	High	When a person chooses and clicks a feature under a category, the next page will provide all the remaining categories. On that page, the person should again choose and click a feature under one of the categories. This process should be reiterated until the person reaches the target product.
	Low	All the categories and features will be presented on the first page only. When a person chooses and clicks a feature among the categories, the next page will provide all the products that belong to the feature without more category offerings.
Breadth	High	A great number of categories
	Low	A small number of categories

Table 4-2 Websites chosen for the study

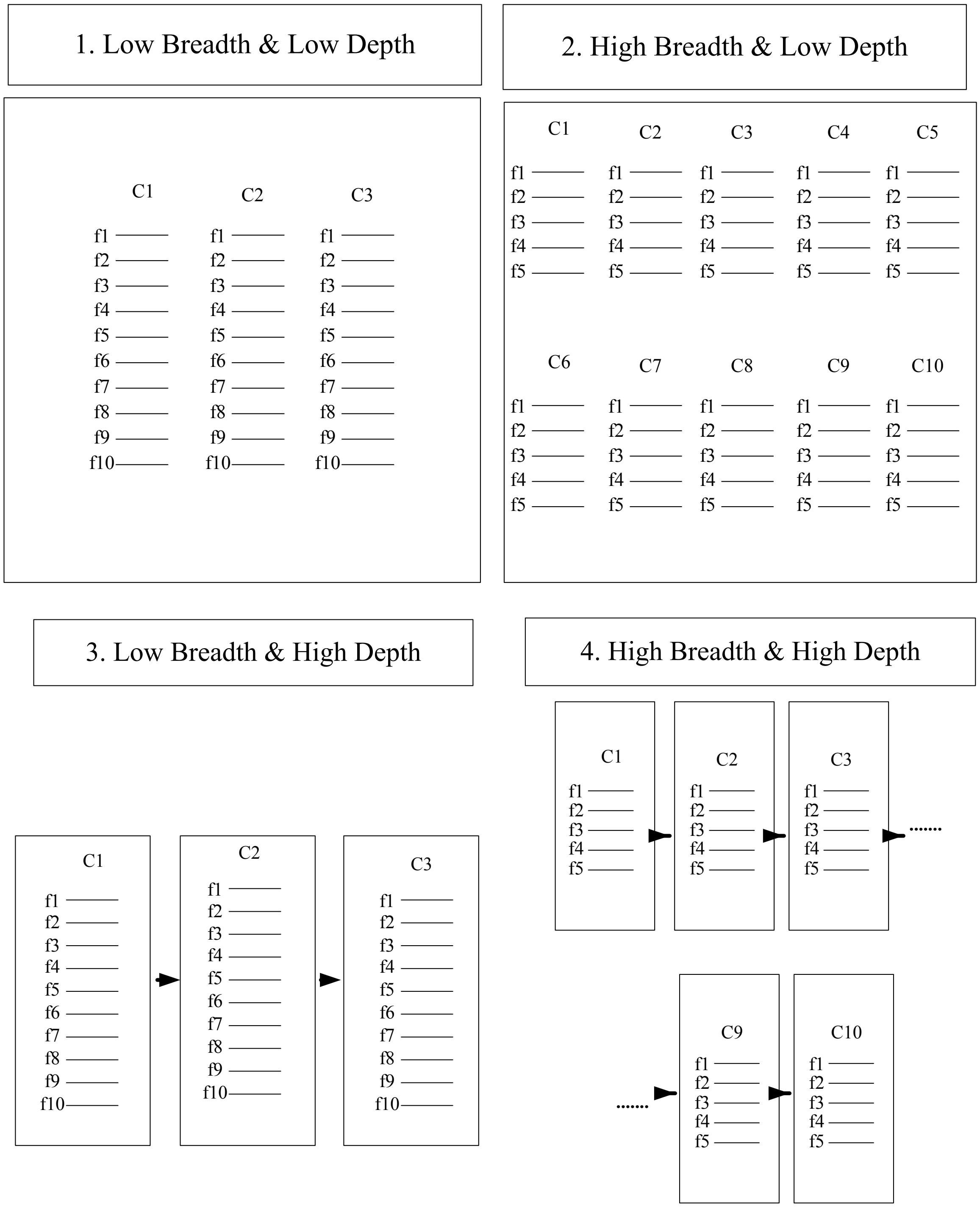
Cell	Sites	Breadth
DH x BH	Lowpriceshopper.com http://www.lowpriceshopper.com/buy/browse__cat_id--402.html	(17)
DL x BH	Jr.com http://sy.adiho.com/ASA/Controller?adi_hasScript=1&_AD_195R22=85&adi_scriptSID=FC02ACE635711B0BCB204C43A6A8C44C&sysid=15&appid=1002&que-FF1=jandr	(11)
DH x BL	Nextag.com http://www.nextag.com/Digital_Cameras~500001z0zBwzmainz5-htm	(6)
DL x BL	Walmart.com http://www.walmart.com/catalog/catalog.gsp?cat=3959&lr=D&path=0%3A3944%3A3959	(3)

Note. DL=Low level of Depth, DH=High level of Depth, BL=Low level of Breadth, BH=High level of Breadth.

Figure 4-1 The combination of interface components

		Breadth of Categories: Low	Breadth of Categories: High
Depth of Categories	Low	1	2
	High	3	4

Figure 4-2 Four interface designs



their start and end times for the task, and the number of pages viewed during the task. Subjects were searched the two digital cameras given in the packet and after the task the plug-in presented to them the questionnaire asking about their experience and perception on the navigation and information search. The Keynote application also stored the response of the survey completed after the task. The samples of four web sites were considered independent between-subjects comparisons. Immediately after the subjects implemented tasks in one of the four sites, they were asked to complete a questionnaire. In the pilot study there were some inappropriate items that misled subjects to unintended responses and they were corrected in desired ones. Measures for the hypotheses testing are presented in Table 4-3.

Table 4-3 Measure Item Sources

Measure Items	Source Reference
[Subjective Web Site Interface Characteristics]	
IFSAT. Interface Satisfaction	(Garrity and Sanders 1994)
IFSAT1 I like using the interface of this Website.	
IFSAT2 This Website has all the functions and capabilities I expect it to have.	
IFSAT3 This Website is user-friendly	
IFSAT4 This Website is easy to navigate	
DNDLY. Website Download Delay	(Palmer 2002)
DNDLY1 The speed in which the Website provided information was fast.	
DNDLY2 The rate at which the information was displayed was fast.	
NVGN. Navigation	(Palmer 2002)
NVGN1 The sequence of obtaining information was clear.	
NVGN2 The information on succeeding links from the initial page was predictable.	
NVGN3 The Web site was not confusing.	
NVGN4 The layout of pages made tasks easier.	
[Cognitive Learning Process]	
DCL. Declarative Knowledge	
DCL1 What is the value and unit "4 Mega Pixel (or 4M)" best representing?	
DCL2 Which category does "SD/MMC card" belong to?	
DCL3 What is the value and unit "3X" best representing?	
DCL4 What are the types of interface between a digital camera and a computer?	
DCL5 What is correct explanation about "camera resolution"?	
PCL. Procedural Knowledge	(Chin 1988)
PCL1 I am satisfied with the speed I found the product.	
PCL2 I did not struggle to find the product.	
PCL3 The route to find the product is well designed to lead me to a specific product.	
PCL4 Learning to operate the site interface is easy.	
PCL5 Finding a product is always straightforward.	
[Task Support Satisfaction]	
TKSAT. Task Support Satisfaction	(Garrity and Sanders, 1994)
TKSAT1 This Web site is more useful than I had expected.	
TKSAT2 Using this Web site enables me to accomplish tasks more quickly	
TKSAT3 This Web site makes it easier to do my task.	
[Self-Efficacy]	
TSE. Task Self-efficacy	(Phillips & Gully, 1997)
TSE1 I feel confident in my ability to search and locate the product in the same Website next time.	
TSE2 I think that I can eventually search and locate a product satisfactorily in this Website.	
TSE3 I feel that I am as capable of finding a product in this Website as well as other students.	
TSE4 I would have to search a product for a long time to be able to find one in this Website.	
CSE. Computer Self-efficacy	(Venkatesh et al. 2003)
CSE1: If there was no one around to tell me what to do as I go.	
CSE2: If I could call someone for help if I got stuck.	
CSE3: If I had a lot of time to complete the job for which the Website was provided.	
CSE4: If I had just the built-in help facility for assistance.	

Chapter 5. Statistical Analysis and Results

Data analysis of the experimental data utilizes two analytical methods: multivariate analysis of variance (MANOVA) and partial least squares (PLS). Each hypothesis may be examined with one or both of the methods, depending on the type of dependent variables. Before we start hypothesis testing, the measurement model of PLS will be assessed below.

The model of the web site interface design attributes and its influence on knowledge acquisition and web site system acceptance is analyzed using PLS, an approach that is suitable with a smaller sample size. PLS allows the testing of the measurement model and the estimation of the structural model. The model in this study is a third-order construct model, including reflective measures for all levels of constructs. We have modeled the items as reflective of corresponding knowledge, as they are highly correlated among themselves, resulting in the fact that they are a representation of the underlying construct (Gefen et al. 2000). PLS-Graph version 3.00 was used to perform the analysis.

There are three reasons to use the Particle Least Square technique (PLS) instead of other Structural Equation Modeling (SEM) techniques of AMOS and LISREL. First, PLS is appropriate to theory building, which is one of the purposes of this study, while covariance-based SEM is appropriate for theory testing. The statistical objective of PLS is to show high R2 and statistical significance of path coefficients (Thompson et al. 1995). On the contrary, the objective of covariance-based SEM is to show that the complete set of paths as specified in the model is conceivable with certain sample data. In other words, the objective of covariance-based SEM is to show that the theory being examined is supported by the data (Bollen 1989). The covariance modeling techniques of AMOS and LISREL are used for comparison of different models based on the exhaustive model, including all constructs and their relationships. In the current study, while some measurement items are employed from previous research, the paths among them in the proposed model are not based on existing theory. Each is hypothesized and tested with Partial Least Square (PLS) in order to assess the operationalization of the theory proposed in this study.

Second, PLS employs a regression analysis approach to test the hypothesized relationships while the AMOS and LISREL approaches draw on the covariance analysis. PLS applies an iterative sequence of Ordinary Least Squares (OLS) and multiple linear regressions, analyzing one construct at a time (Thompson et al. 1995). Rather than estimating the variance of all the observed variables, as in covariance-based SEM, PLS estimates the parameters in such a way that will minimize the residual variance of all the dependent variables in the model (Chin 1998). Therefore, PLS is more suited for predictive applications and theory building of this study, in contrast to covariance-based SEM.

Third, PLS analysis can assess a model with a relatively small number of samples. The sample size of AMOS or LISREL is relatively large because it is determined based on the number of estimated parameters in a structural model. PLS is less affected by small sample sizes and is also less influenced by deviations from multivariate normal distribution. None of the PLS significance estimation methods require parametric assumptions (Gefen et al. 2000). PLS is thus especially suited for the analysis of small data samples and for data that does not necessarily exhibit the multivariate normal distribution required by covariance-based SEM (Chin 1998). One guideline for such a sample size in PLS is that the sample should have at least ten times more data-points than the number of items in the most complex construct in the model (Thompson et al. 1995). The sample characteristics are presented in Table 5-1.

5.1. Assessment of Measurement Model

The descriptive statistics of the experimental data are shown in Table 5-2. Measurement model assessment is accomplished in two steps: convergent validity and discriminant validity analysis. According to Fornell and Larcker (1981), convergent validity of scale items was examined by three criteria: First, composite construct reliabilities should be greater than 0.80. From Table 5-3, we can see that composite reliabilities of all constructs also exceed the required minimum of 0.80. Second, all item factor loadings should exceed 0.70. As in Table 5-4, factor loadings for all scale items exceed the minimum-loading criterion of 0.70. Third, average variance extracted (AVE) for each construct should exceed 0.50. AVE values of all constructs exceed the threshold value of 0.50. Therefore, all three conditions for convergent validity were met.

Discriminant validity is examined by determining if (1) the indicators load more strongly on their own constructs than on other constructs in the model, and (2) the constructs share more variance with their own measures than they share with the other constructs in the model (Bassellier et al. 2004). The percent of variance captured by a construct is given by its average variance extracted (AVE). To show discriminant validity, each construct square root of the AVE has to be larger than its correlation with other factors (Gefen et al. 2000). All constructs meet this requirement as shown in Table 5-3. Thus, all constructs display adequate reliability and discriminant validity.

Results for the measurement model support the validity and reliability of the 24-item instrument for web site interface attributes and customer response on learning and system acceptance.

Table 5-1 Sample Characteristics

Age

	Frequency	Percent
< 20	11	5.5
20 - 24	166	83
25 - 29	16	8
30 - 34	3	1.5
35 - 39	1	0.5
40 - 44	3	1.5
>45	0	0
Total	200	100

Gender

	Gender	
	Frequency	Percent
Male	122	61
Female	78	39
Total	200	100

Experience

	OWNDG		TRYBUY		VSTWEB	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	122	61	131	65.5	162	81
No	78	39	69	34.5	38	19
Total	200	100	200	100	200	100

OWNDG: Ownership of digital camera
TRYBUY: Chance to search information about digital camera
VSTWEB: Chance to visit Websites selling digital camera

Table 5-2 Descriptive Statistics

Construct	Mean	Std. Deviation
Browsing Time (BT)	258.965	193.969
Pages per View (PV)	11.480	10.042
Browsing Time per Page Viewed (BTP)	29.411	46.956
Last Time Own Digital Camera (OWNTM)	4.803	1.296
Last time to try to purchase product (TRYTM)	3.664	1.455
Expertise on product (EXPRT)	3.630	1.488
Last time to visit the website (VSTTM)	3.340	1.496
Interface Support Satisfaction (IFSAT)	4.763	1.415
Procedural Knowledge (PCL)	4.509	1.632
Download Delay (DNDLY)	5.543	1.386
Navigation (NVGN)	4.868	1.379
Better Than the Best Website Interface (BESTIF)	3.070	1.691
Sufficient Knowledge Provision (SUFF)	5.010	1.486
Better than Average Website Interface (AVG)	4.200	1.547
Declarative Knowledge (DCL)	4.008	1.209
Task Support Satisfaction (TKSAT)	4.788	1.495
Task Self-Efficacy (TSE)	5.302	1.417
Computer Self-Efficacy (CSE)	5.344	1.370

Notes: All constructs except BT, PV, BTP, OWNTM, TRYTM, EXPRT, VSTTM, and DCL are seven-point scales with the anchors 1 = Strongly disagree, 4 = Neutral, 7 = Strongly agree. The other scales are presented in Appendix.

Table 5-3 Inter-Construct Correlations

	Composite Reliability (# of items)	IFSAT	DNDLY	NVGN	PCL	TSE	CSE	DCL	TKSAT
IFSAT	0.934 (4)	0.884							
DNDLY	0.946 (2)	0.557	0.948						
NVGN	0.886 (2)	0.720	0.573	0.892					
PCL	0.917 (4)	0.713	0.518	0.730	0.857				
TSE	0.913 (3)	0.624	0.512	0.656	0.538	0.887			
CSE	0.917 (4)	0.465	0.393	0.556	0.470	0.738	0.857		
DCL	1.000 (1)	0.049	0.060	0.131	0.075	0.121	0.078	1.000	
TKSAT	0.946 (3)	0.608	0.446	0.692	0.564	0.722	0.615	-0.043	0.924

Note. 1. Composite Reliability = CR = $(\sum\lambda_i)^2 / [(\sum\lambda_i)^2 + \sum_i var(\epsilon_i)]$, where : λ_i is the component loading to an indicator and $var(\epsilon_i) = 1 - \lambda_i^2$

2. The numbers on the leading diagonal are the square root of the variance shared between the constructs and their measures (AVE= $\sum\lambda_i^2$ / $[\sum\lambda_i^2 + \sum_i var(\epsilon_i)]$). Off diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be larger than off-diagonal elements.

3. The acronyms are: IFSAT (interface support satisfaction), DNDLY (download delay), NVGN (navigation), PCL (procedural knowledge), TSE (task self-efficacy), CSE (computer self-efficacy), DCL (declarative knowledge), TKSAT (task support satisfaction).

Table 5-4 PLS Outer Model Loadings

Internal Consistency Reliability and Factor Loadings of Measurement Items in Substantive Model*

Construct and items	Factor loading	Composite scale reliability	Average variance extracted
IFSAT			
IFSAT1	0.859	0.934	0.781
IFSAT2	0.868		
IFSAT3	0.921		
IFSAT4	0.886		
DNDLY			
DNDLY1	0.956	0.946	0.898
DNDLY2	0.940		
NVGN			
NVGN4	0.909	0.886	0.796
NVGN1	0.875		
PCL			
PCL1	0.840	0.917	0.735
PCL2	0.878		
PCL3	0.898		
PCL5	0.813		
TSE			
TSE1	0.882	0.917	0.787
TSE2	0.874		
TSE3	0.889		
CSE			
CSE1	0.856	0.917	0.734
CSE2	0.856		
CSE3	0.906		
CSE4	0.807		
TKSAT			
TKSAT1	0.911	0.946	0.854
TKSAT2	0.921		
TKSAT3	0.939		
DCL			
DCL1235	1.000	1.000	1.000
EXPRT			
EXPRT	1.000	1.000	1.000

* All loadings are significant at less than .001 (one-tailed tests).

Note. The acronyms are: IFSAT (interface support satisfaction), DNDLY (download delay), NVGN (navigation), PCL (procedural knowledge), TSE (task self-efficacy), CSE (computer self-efficacy), DCL (declarative knowledge), TKSAT (task support satisfaction), EXPRT (expertise on products).

5.2. Test of the Structural Model

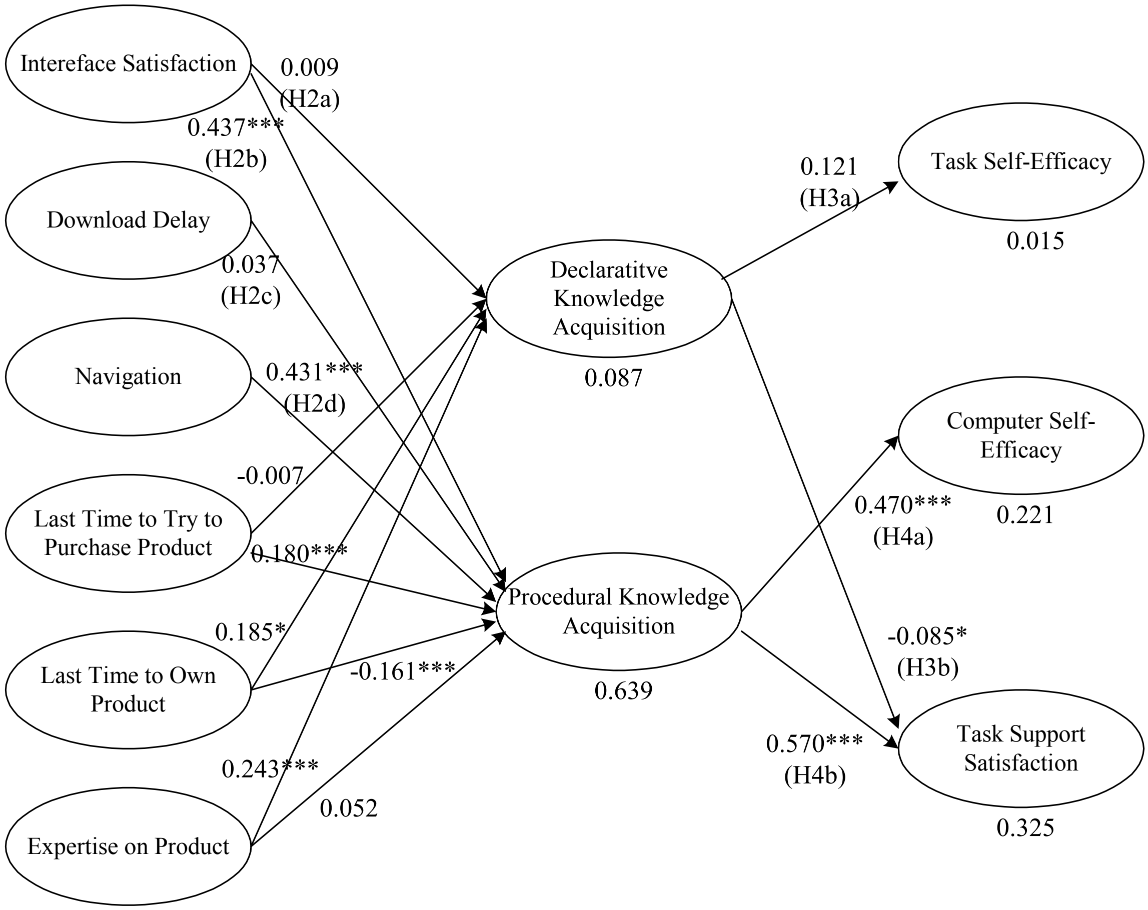
A bootstrapping procedure was used to generate t-statistics and standard errors (Chin 1998). With the hypotheses being unidirectional, statistical tests were assessed at the 1 percent level of significance, using a one-tailed t-test. A test of the structural model was used to assess (1) the structure of web site interface design and (2) the influence of web site interface on the customer's learning and system acceptance.

In a PLS structural model, loadings of measures of each construct can be interpreted as loadings in a principal components factor analysis. Paths are interpreted as standardized beta weights in a regression analysis. The path coefficients and explained variances for the model are shown in Figure 5-1.

All the constructs were modeled as reflective, and most of the constructs in the model were measured using multiple indicators, especially those included in the PLS analysis. The only exceptions are the declarative knowledge (DCL) dimension, which is represented by the number of correct answers from multiple questions on facts about digital cameras. The outer model loadings of all other items on their respective constructs are shown in Table 5-4.

Subjective characteristics of web site interface, including interface support satisfaction (IFSAT), download delay (DNDLY), and navigation (NVGN) and control variables, such as the last time to search information on digital cameras (TRYTM), the last time one owned a digital camera (OWNTM), and the evaluation of one's expertise of digital cameras (EXPERT), together explain 63.9 percent of the variance in procedural knowledge acquisition (PCL), while interface support satisfaction (IFSAT) and all the

Figure 5-1 Partial Least Square Results



* p<.10
** p<.05
*** p<.001

control variables explain only 8.7 percent of the variance in declarative knowledge acquisition of the product (DCL). The possible rationales for the small amount of explained variance will be discussed in the hypotheses testing sections. Procedural knowledge acquired (PCL) accounts for 22.1 percent of the variance in computer self-efficacy (CSE); procedural knowledge and declarative knowledge of product together account for 32.5 percent of the variance in task support satisfaction (TKSAT); and declarative knowledge of the product accounts for only 1.5 percent of task self-efficacy

(TSE). Tests for each hypothesis will be discussed in the next section with the supplemental statistical analysis, such as the chi-square test and multivariate analysis of variance (MANOVA).

5.3. Hypotheses testing

5.3.1. Chi-square analysis and ANOVA

Means and standard deviations of dependent variables and multivariate test of significance are shown in Table 5-5 and 5-6 respectively. Declarative knowledge activation of the product is operationalized to time spent in finding the two products, divided by the number of pages viewed during the task (BTP). The measure intends to standardize time spent per page view. Table 5-7 shows there is no significant difference in time spent per page during the task between high-category and low-category ($F=0.863$, $p<.354$) (H1a). That is, the activation time between the two groups has no difference.

The first measure that quantifies procedural knowledge is whether or not subjects succeed in finding the two digital cameras (S). The different success rates of the task, in two distinct levels of guidance, were analyzed through the chi-square test, as in Table 5-8. In that table, the number of those who succeed in finding the two digital cameras

Table 5-5 Means and Standard Deviations of Dependent Variables

	CAT	GD	Mean	Std. Deviation	N
BTP	Low	Low	28.118	39.592	44
		High	37.875	77.376	43
		Total	32.940	61.088	87
	High	Low	30.245	39.177	43
		High	22.659	12.824	50
		Total	26.166	28.333	93
SUFF	Low	Low	5.020	1.355	44
		High	5.140	1.441	43
		Total	5.080	1.391	87
	High	Low	4.930	1.791	43
		High	5.220	1.282	50
		Total	5.090	1.537	93
AVG	Low	Low	3.860	1.374	44
		High	4.530	1.202	43
		Total	4.200	1.328	87
	High	Low	4.160	1.758	43
		High	4.680	1.449	50
		Total	4.440	1.612	93
DCL	Low	Low	4.116	1.254	44
		High	4.072	1.046	43
		Total	4.094	1.150	87
	High	Low	3.656	1.450	43
		High	4.082	1.115	50
		Total	3.885	1.291	93
PCL	Low	Low	3.994	1.667	44
		High	4.924	1.628	43
		Total	4.454	1.704	87
	High	Low	4.436	1.776	43
		High	4.925	1.301	50
		Total	4.699	1.550	93

Note. Acronyms are procedural knowledge acquisition (PCL), declarative knowledge acquisition of product (DCL), number of pages viewed during the task (BTP), sufficient knowledge regarding digital cameras (SUFF), interface design better than that of other average websites (AVG).

Table 5-6 Multivariate Test of Significance

Effect	Wilk's Lambda	F	Hypothesis df	Error df	Sig.
Breadth	0.977	0.814	5	172	0.541
Depth	0.925	2.806	5	172	0.018
Breadth *Depth	0.975	0.881	5	172	0.495

Table 5-7 Univariate Tests of Significance: Between Subject Variables

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	BTP	5463.437	3	1821.146	0.819	0.485
	SUFF	2.239	3	0.746	0.344	0.793
	AVG	18.691	3	6.230	2.927	0.035
	DCL	6.210	3	2.070	1.386	0.249
	PCL	27.036	3	9.012	3.554	0.016
Intercept	BTP	158410.606	1	158410.606	71.235	0.000
	SUFF	4623.516	1	4623.516	2132.938	0.000
	AVG	3331.090	1	3331.090	1564.978	0.000
	DCL	2842.164	1	2842.164	1903.390	0.000
	PCL	3744.449	1	3744.449	1476.651	0.000
Breadth	BTP	1919.896	1	1919.896	0.863	0.354
	SUFF	0.002	1	0.002	0.001	0.978
	AVG	2.212	1	2.212	1.039	0.309
	DCL	2.271	1	2.271	1.521	0.219
	PCL	2.192	1	2.192	0.865	0.354
Depth	BTP	52.833	1	52.833	0.024	0.878
	SUFF	1.852	1	1.852	0.855	0.357
	AVG	15.828	1	15.828	7.436	0.007
	DCL	1.638	1	1.638	1.097	0.296
	PCL	22.565	1	22.565	8.899	0.003
Breadth*Depth	BTP	3370.562	1	3370.562	1.516	0.220
	SUFF	0.335	1	0.335	0.155	0.695
	AVG	0.266	1	0.266	0.125	0.724
	DCL	2.475	1	2.475	1.658	0.200
	PCL	2.181	1	2.181	0.860	0.355
Error	BTP	391382.327	176	2223.763		
	SUFF	381.511	176	2.168		
	AVG	374.620	176	2.129		
	DCL	262.805	176	1.493		
	PCL	446.296	176	2.536		
Total	BTP	552858.998	180			
	SUFF	5035.000	180			
	AVG	3756.000	180			
	DCL	3129.050	180			
	PCL	4250.000	180			
Corrected Total	BTP	396845.764	179			
	SUFF	383.750	179			
	AVG	393.311	179			
	DCL	269.015	179			
	PCL	473.332	179			

Note. Acronyms are procedural knowledge acquisition (PCL), declarative knowledge acquisition of product (DCL), number of pages viewed during the task (BTP), sufficient knowledge regarding digital cameras (SUFF), interface design better than that of other average websites (AVG).

Table 5-8 Depth * Success Crosstabulation

		Success		Total	Chi-Square	
		Failed	Succeeded		Value	Significance
Depth	High	18	74	92	25.252	0.000
	Low	51	41	92		
Total		69	115	184		

(n=74) is much greater than those who failed to find the products (n=18), when they are given a web site designed with more guidance (χ^2=25.252, p<.000) (H1b). On the contrary, the number of those who failed (n=51) was slightly greater than the number of those who succeeded (n=41), when they were asked to find the cameras on a web site designed with less guidance. This implies that people can search and locate what they want on a web site when they are well guided with the intended web site interface design. That is, if the web site can give customers a clear idea about the link they should click on, they will have an outstanding probability of success in finding a product they want, and, therefore, in purchasing the product from the web site.

The second measure for this hypothesis is how people perceive procedural knowledge on a web site (PCL). An average of four questionnaire items was the measure used for the MANOVA in Table 5-7, while each of the four items was entered to be analyzed in PLS. Analysis of variance of this alternative dependent variable did support H1b (F=8.899, p<.003). People perceived a web site as more helpful in getting the procedural knowledge when the web site interface is sophisticated with navigation guidance. This is also supported by the fact that the web site having a high level of guidance is perceived to have an interface design better than that of other average web sites (AVG) ($F=7.436$, $p<.007$).

The third dependent measure for this hypothesis (H1b) is, again, the standardized time spent for the navigation to find the products (BTP). It is hypothesized that the time will be shorter on a web site with more intended guidance than one with less guidance. BTP is considered one of the dependent variables that directly measures procedural knowledge acquisition, as completing a task will be automated because of procedural compilation; hence, the speed in finishing a task will be faster. Table 5-7 shows, however, that this hypothesis is not supported. It did not take more time for subjects to complete a task on a web site with more guidance than one with less guidance ($F=.024$, $p<.878$). It is probable, again, that time needed to find two products on a web site is too short for subjects to be influenced by the intervention of guided navigation.

The acquisition of declarative knowledge of the product may be quantified with the success of task completion. If customers cannot obtain the appropriate knowledge about a product, they may not reach the targeted products. In this case, the dependent variable is the success of finding the two digital cameras (S). Table 5-9 shows that the number of those subjects who succeeded in finding the two digital cameras (n=71) is significantly greater than those who could not find the two digital cameras (n=25) when the subjects were given a web site with a greater number of categorical information ($\chi^2=11.244$, $p<.001$), while the number of subjects who succeeded (n=44) and failed (n=44) in the task were the same on web sites with a low level of categorical information. This shows there is significant difference between the customers' navigation behavior among web sites having a larger or smaller amount of declarative knowledge of the product (H1c). If a web site provides a full range of product information in a well-organized way, the commercial firm can allow the customers to find the best product by themselves, and eventually be led to buy the product.

Table 5-9 Breadth * Success Crosstabulation

		Success		Total	Chi-Square	
		Failed	Succeeded		Value	Significance
Breadth	High	25	71	96	11.244	0.001
	Low	44	44	88		
Total		69	115	184		

The dependent measures for the hypothesis H1c are the number of correct answers to questions about digital cameras, including simple facts and inferential knowledge (DCL). The supplemental measure for this hypothesis was the subjects' perceptions of whether or not the web sites provide sufficient knowledge about digital cameras (SUFF). The result (Table 5-7) shows that customers who visit a web site with a list of a great number of categories about digital cameras do not acquire declarative knowledge of the product (DCL) better than those who visit a web site with a small number of categories ($F=1.521$, $p<.219$) (H1c). This result is contrary to what is expected, probably because the questions about digital cameras are so straightforward and depend, to a great extent, on the subjects' ownership of digital cameras or the expertise level of their knowledge of digital cameras. In order to exclude the influence of the type of questions asked, the second measure for acquisition of declarative knowledge of the product is quantified by the subjects' perception of the provision of sufficient knowledge from the web sites (SUFF). In opposition to the hypothesis, people consider that they are not provided more knowledge on a web site designed with more guidance ($F=.011$, $p<.978$). A possible explanation for this result is that the duration for finding two digital cameras was relatively short to allow them to explore the web site interface design, so the effect of the guidance level might not be fully achieved.

5.3.2. PLS Analysis

The effect of previous expertise on the knowledge of digital cameras on the acquisition of declarative knowledge of the product is shown in the PLS analysis (Figure 5-1). The higher the subjects' perceived expertise level of knowledge of digital cameras (EXPRT), the greater the number of correct answers to the question about facts or inference on digital cameras (β=0.243, t=3.3005, p<.001) (H1c). The ownership of digital cameras or previous searching for information on digital cameras, however, did not show any effect on the acquisition of declarative knowledge of the product.

Whether or not customers are satisfied with the e-commerce web site interface design does not prove to be positively related to declarative knowledge acquisition (β=.009, t=.1486, p>.10) (H2a). This, again, must be associated with the low explained variance of declarative knowledge of the product, which implies there are other substantive variables that influence the type of knowledge. More variables should be found and included in this model to control unexplained variances. The incomplete capture of knowledge on digital cameras might be another issue on the non-significant result of this hypothesis.

PLS analysis was utilized to assess the hypotheses on subjective evaluations of web sites and acceptance of Web information systems. Interface quality satisfaction is one of the major measures of interface design of systems, in general. It was adjusted to the current web site evaluation circumstances. Figure 5-1 shows the path model of the hypothesized relationships among constructs. The convergent and discriminate reliability of constructs are presented in Table 5-4. Interface quality satisfaction (IFSAT) has a positive relationship with procedural knowledge (PCL) ($\beta=0.437$, $t=4.5745$, $p<.001$) (H2b). Items of IFSAT are listed in the questionnaire items in the Appendix. When people like the interface of the web site, feel the web site has all the functions and capabilities they expect it to have, consider the web site user-friendly, and regard the web site as easy to navigate, they think the procedure of the web site is well designed to lead them to reach a product for which they are looking.

When the web site download delay (DNDLY) is higher, people will perceive that the web site does not help them obtain appropriate procedural knowledge. This hypothesis was not supported in PLS analysis ($\beta=.037$, $t=.5645$, $p>.10$) (H2c). This result implies that even though a web site loads information at a relatively slow speed, people will not consider it to be keeping them from obtaining procedural knowledge on the web site.

The effect of web site navigation (NVGN) efficiency on procedural knowledge acquisition was significant ($\beta=0.431$, $t=5.3121$, $p<.001$) (H2d). As presented in items of the NVGN construct, people think they are provided with more procedural knowledge when they feel it is easy to navigate a web site.

The relationship between acquisition of declarative knowledge of the product and task self-efficacy was not supported ($\beta=.121$, $t=1.2718$, $p>.10$) (H3a). The questions on digital cameras (DCL) were quite easy for the subjects to answer, or depended much on the knowledge level of each individual, so it probably has a ceiling effect of short range of variance.

The relationship between acquisition of procedural knowledge and computer self-efficacy is strongly supported, as expected, in H3b (β=0.470, t=9.2000, $p<.001$). It is proven that people feel confident in their skill of web site operation when they are provided with more procedural knowledge from the web site.

On the contrary to hypothesis H3a, the acquisition of declarative knowledge of the product (DCL) was not positively related to task support satisfaction (β=-0.085, t=1.6704, $p<.10$) (H4a). Even if the relationship was proven statistically significant, the direction of the relationship was the opposite. A possible explanation for this unexpected result must be the low explanation power of DCL (R^2=8.7%). The questions about the digital camera were quite straightforward, and they were strongly related to previous expertise on digital cameras (EXPRT->DCL: $p<.001$). In future research the question items should be varied.

As expected, when subjects were provided with more procedural knowledge, they were more satisfied with the task support from the web site (β=0.570, t=11.4818, $p<.001$) (H4b). When we consider that the knowledge necessary to complete a task is declarative, and offers procedural knowledge of the product, this result implies that if a web site is well designed to provide procedural knowledge to customers, it also will cause them to find products they want to buy with less effort, and an actual purchase may be realized.

Chapter 6. Discussion and Conclusion

The hypotheses posed in this study were partially supported with PLS and MANOVA analyses. The summary of the hypotheses testing and findings are presented in Table 6-1.

The main variables centered in the suggested model are declarative and procedural knowledge acquired during task completion on a commercial web site. The task was to search and locate information about digital cameras on a web site having different levels of categories (breadth) and guidance (depth). Most of the hypotheses related to declarative knowledge acquisition; however, they were found to be not statistically significant in both PLS and MANOVA analyses. The first probable reason might be the fact that declarative knowledge of product was not measured correctly. Face or construct validity must be examined in detail before the survey. The questions asked in order to measure declarative knowledge of a product might have been so easy that there could have been a ceiling effect for them, or they could have been answered correctly with merely a guess. Either way, the items might not have measured the fair declarative knowledge of the product that we truly want to measure. This will be further explored and altered in future research.

The second possible reason might be the lack of control variables that seemingly influence knowledge acquisition, but were not included in the model. This claim is partly supported by the statistically significant effect of expertise on declarative knowledge of a product. Customers with previous knowledge of digital cameras found it much easier to answer the questions, which might lower the power of the web site interface attribute on

Table 6-1 Summary of Hypotheses Testing

Hypothesis (PLS model)	Support (DV: Analysis Method)
H1a. As the number of categories and features of product increases (high level of breadth), the declarative activation will decrease.	Not Supported (DCL: MANOVA)
H1b. As an interface guides the customer to locate the product better, customers achieve production compilation more effectively.	Supported (S: Chi-Square test) Supported (PCL: MANOVA) Supported (AVG: MANOVA) Not Supported (BTP: MANOVA)
H1c. As breadth increases, long-term declarative knowledge also increases.	Supported (S: Chi-Square test) Not Supported (DCL, SUFF: MANOVA) Control: EXPRT (significant): PLS
H2a. Interface Satisfaction will enhance declarative knowledge acquisition. (IFSAT->DCL)	Not Supported (DCL: PLS)
H2b: Interface Satisfaction will enhance procedural knowledge. (IFSAT->PCL)	Supported (PCL: PLS)
H2c: Website Download Delay will be negatively related with procedural knowledge. (DNDLY->PCL)	Not Supported (PCL: PLS)
H2d: Navigation effectiveness will be positively related to procedural knowledge. (NVGN->PCL)	Supported (PCL: PLS)
H3a. An increase in declarative knowledge acquired during task performance will increase affective learning outcome, task self-efficacy. (DCL->TSE)	Not Supported (TSE: PLS)
H3b. Fast compilation will enhance computer self-efficacy. (PCL->CSE)	Supported (CSE: PLS)
H4a. Enhanced long-term declarative knowledge will make you perceive the Web information system to	Not Supported (TKSAT: PLS) Control: EXPRT (significant)
H4b: The enhanced procedural knowledge will positively affect Task Support Satisfaction. (PCL->TKSAT)	Supported (TKSAT: PLS)

Note. Acronyms are procedural knowledge acquisition (PCL), declarative knowledge acquisition of product (DCL), number of pages viewed during the task (BTP), sufficient knowledge regarding digital cameras (SUFF), interface design better than that of other average websites (AVG), IFSAT (interface support satisfaction), DNDLY (download delay), NVGN (navigation), PCL (procedural knowledge), TSE (task self-efficacy), CSE (computer self-efficacy), TKSAT (task support satisfaction), EXPRT (expertise on products), DV (dependent variable), PLS (partial least square). Statistical significance of support level is 5%.

knowledge acquisition. The explanation of the low variance also supports this argument, as it would have been much higher if more control variables had been included in the model.

In contrast, procedural knowledge-related hypotheses almost always were supported by statistical analysis. The variance explained by the web site interface characteristics was more than 60 percent. We can conclude from this result that procedural knowledge (which is "how-to-do" knowledge) is easily influenced by related web site interface design, and also has an effect on web site system satisfaction and self-efficacy. This implies that practitioners (such as web site designers, e-business entrepreneurs, and CEOs or managers of e-commerce companies) should pay attention to the functional design aspect that enhances the customers' cognitive learning process for collecting product information, in order to facilitate their staying longer and eventually purchasing products on the web sites. It's time to have more research on not only the aesthetic aspect of web site design, but also on how to make an e-commerce web site that helps customers who shop in a virtual store.

The current study will bridge the prior psychological findings on the cognitive learning process and the understanding of production information on an electronic commerce web site. Electronic commerce web site navigation requires customers' mental modeling and cognitive effort to find and purchase a product. The mental endeavor is greater than offline shopping, because the only channel customers can face is the interface between their eyes and the combination of text and graphics of the web site. The electronic firm also puts considerable resources into the interface design of electronic malls, just as the offline stores spend huge amounts of money on planning interior routes to entice more customers to buy products. Because all of these endeavors also should be applied to the two-dimensional web site, business-to-customer web sites become too complex to explore the provided information on products. This again exhausts customers' mental energy. The proposed cognitive learning model in this study will reduce customers' mental efforts and eventually lead them to make purchases on the current web site. A research framework presented in this study will help researchers conduct future research on electronic store design.

There has been a lack of research on the effect of usability evaluation criteria on users concerning the way they navigate web sites, acquire information, and target the product they want. The main studies on web usability evaluation are still too concentrated on finding dimensions of usability testing (Lavie et al., 2004) and evaluating method framework (Andre et al., 2001; Hartson et al., 2001; Smith et al., 1997). In particular, the effect of web site usability on customers' navigation behavior on a commercial web site has been rarely studied. The research question is driven by web site managers and designers, and hence should be given more attention by researchers.

It has been our aim that this study will lead to finding the missing link between technology features and the cognitive process variables that influence information learning outcomes. E-commerce research on web site interface design needs to address the ways in which technology features can engage the psychological processes of learning that will, in turn, produce the desired learning outcomes.

6.1. Future Research

Ubiquitous computing is becoming a new paradigm in the current digital economy. We will be able to control home appliances from cell phones or laptop computers through the Internet or any other network; we also will be able to find the same information from any digital equipment.

Two critical characteristics of ubiquitous computing are mobility and integration. All digital equipment will be carried with you wherever you go, connected to the source of information all the time. Hence, you will be able to search for information you want and control the remote devices. For instance, you will be able to search your personal financial information, such as bank statement, loan balance, and payment schedule while you walk down the street. In case you forgot to pay your monthly mortgage and you realize it while you're riding the subway, you can take care of the matter right then and there.

You can be informed who came into you house, and which appliances are turned on, while you're at your work place. You do not need to worry about your home security anymore. You even can get the message left on you home phone while you have lunch with your friends. The cell phone is in the center of this paradigm shift. Its small size allows mobility. It will let you connect to networks, including the Internet, that contain any information you want. You can carry it wherever you go. We know that the cell phone is not simply a voice communicator any more. You can use it to take a picture and save the digital copy. You can talk to your friends with data messenger. You can even watch a movie or listen to music with a cell phone. These functions will be expanded greatly to play many more imaginable roles very soon.

The other dimension of ubiquitous computing is integration. Some functions are possible already, but much more is coming. We will be able to visit a bank's web site to transfer balances to other banks. Using a unique network and equipment, we will be able to check our home security. An agent providing an information service is independent of the one who is in charge of other types of information services. The information should be able to be integrated into one source, at least from the perspective of users, while it is not feasible to unite those agents with different business aims.

The Internet is the most feasible candidate to implement this mission. As of now, it is the largest source of information. The information floating in the Internet will be integrated somehow, and will be searched with the most advanced search engine. The information found will be adjusted to your need, and delivered to you in the best interface. Digital devices, including mobile phones, should be able to connect to the information source with the lowest cost and effort, so you can utilize it exactly the way you want.

The interface of ubiquitous computing will play a crucial role in the planning phase. The device and source of information will be integrated into a single unit. However, searching and reproducing the information conforming to your needs will require complex mechanisms behind the scene. In this case, interface is not only the issue of how to present, but also how to integrate, the information. The digital devices, including cell phones and other equipment that will communicate with the end-device, are important to elicit the users' convenience and attention. Digital devices are getting smaller and smaller, and the number of functions they contain is getting greater. If the digital device is too complicated to utilize all the embedded functions, you will use only its visible and simple functions; the rest of them are useless. You will not even know if there are other functions. This is a very common failing of expensive digital devices. The interface design effort should resolve the trade-off of simple operation and multiple functionalities. Simple and convenient interface design does not mean you should get rid of some of the device's functions. Good interface design will allow the users to take advantage of all the functions included in the device with a minimal number of operations. The interface also should let the users learn to use the device very quickly and easily. Digital devices no longer are usable for many years. They are replaced often by new models and new technologies, so we don't want to spend substantial time getting familiar with them. The standard interface common to similar types of devices helps you understand the functions in a relatively short time. Thus, a sophisticated interface design for similar type of devices will solve the issue.

The importance of interface design also applies to web sites. They are the first gate that users encounter when they try to find information or products they want. In the ubiquitous computing environment, the well-designed interface design of a web site will be able to be transformed to the new interface without additional effort and costs. The interface is about ways to deliver the information to the users as they want. If this is decided successfully, the same can be applied to the new device. The only work necessary work will be to adjust them into the new device. Here, navigation design is important, to determine the algorithm to find the information users want. Even when the users do not know exactly what they want to search, the well-designed interface will be able to deliver the best answer to them with the cumulated experience and learning.

Research on interface design of web sites can be applied to voice communication or virtual reality. In ubiquitous computing, the information gathered from an information search will be delivered to the users through voice communication. Voice query and voice output may be the simplest interactions between human beings and information sources. In this case, the only difference from a human search of the information is that the player who searches and integrates the information is a machine agent. Another presentation type in the future will be virtual reality. Here, people will touch and operate the product or service in 3D reality, as if they are real. In these cases, agents other than humans will navigate the information source to find the most appropriate information. However, the navigation and algorithm are the same as when you search a web site and find the information by yourself. The goal of the interaction is find the necessary information the best way. The research on web site interface is to allow you to navigate and search the web site most efficiently, and ultimately find the best answer to your query.

In the rapidly changing digital economy, we can hardly anticipate the future wave of business. Technology is advancing at unpredictable speed and direction. However, technology is only meaningful when it interacts successfully with humans. The digital economy is not driven by technology itself but by human beings who utilize the technology for their own needs. Therefore, exploring what they want to do with the technology and how they respond to the existing technology will show you the future digital economy. The ongoing research on how people interact with technology also will give you ideas on new electronic business models that will resolve the current conflict between technological advance and the social system.

APPENDIX 1

TABLES AND FIGURES

Table 3-1 Definitions of Training-Related Knowledge (excerpted from Olfman et al. (1994b))

	Conceptual		Procedural	
Author(s)	**Term**	**Definition**	**Term**	**Definition**
Anderson (1982)	Declarative	Knowledge of facts	Procedural	Knowledge of how to do things
Kieras & Poison (1985)	How-it-works	A hierarchy of concept explanations	How-to-do-it	Knowledge of various tasks
Hiebert & Lefevre (1987)	Conceptual	Knowledge of relationships between pieces of information	Procedural	A formal language and rules for completing tasks
Charney & Reder (1987)	Conceptual + Usage	Knowing what procedures exist and circumstances for applying procedures	Procedural	Knowing how to carry out procedures

Table 4-1 Operationalization of interface attribute

Manipulation	Level	Definitions
Depth	High	When a person chooses and clicks a feature under a category, the next page will provide all the remaining categories. On that page, the person should again choose and click a feature under one of the categories. This process should be reiterated until the person reaches the target product.
	Low	All the categories and features will be presented on the first page only. When a person chooses and clicks a feature among the categories, the next page will provide all the products that belong to the feature without more category offerings.
Breadth	High	A great number of categories
	Low	A small number of categories

Table 4-2 Websites chosen for the study

Cell	Sites	Breadth
DH x BH	Lowpriceshopper.com http://www.lowpriceshopper.com/buy/browse__cat_id--402.html	(17)
DL x BH	Jr.com http://sy.adiho.com/ASA/Controller?adi_hasScript=1&_AD_195R22=85&adi_scriptSID=FC02ACE635711B0BCB204C43A6A8C44C&sysid=15&appid=1002&que-FF1=jandr	(11)
DH x BL	Nextag.com http://www.nextag.com/Digital_Cameras~500001z0zBwzmainz5-htm	(6)
DL x BL	Walmart.com http://www.walmart.com/catalog/catalog.gsp?cat=3959&lr=D&path=0%3A3944%3A3959	(3)

Note. DL=Low level of Depth, DH=High level of Depth, BL=Low level of Breadth, BH=High level of Breadth.

Table 4-3 Measure Item Sources

Measure Items	Source Reference
[Subjective Web Site Interface Characteristics]	
IFSAT. Interface Satisfaction	(Garrity and Sanders 1994)
IFSAT1 I like using the interface of this Website.	
IFSAT2 This Website has all the functions and capabilities I expect it to have.	
IFSAT3 This Website is user-friendly	
IFSAT4 This Website is easy to navigate	
DNDLY. Website Download Delay	(Palmer 2002)
DNDLY1 The speed in which the Website provided information was fast.	
DNDLY2 The rate at which the information was displayed was fast.	
NVGN. Navigation	(Palmer 2002)
NVGN1 The sequence of obtaining information was clear.	
NVGN2 The information on succeeding links from the initial page was predictable.	
NVGN3 The Web site was not confusing.	
NVGN4 The layout of pages made tasks easier.	
[Cognitive Learning Process]	
DCL. Declarative Knowledge	
DCL1 What is the value and unit "4 Mega Pixel (or 4M)" best representing?	
DCL2 Which category does "SD/MMC card" belong to?	
DCL3 What is the value and unit "3X" best representing?	
DCL4 What are the types of interface between a digital camera and a computer?	
DCL5 What is correct explanation about "camera resolution"?	
PCL. Procedural Knowledge	(Chin 1988)
PCL1 I am satisfied with the speed I found the product.	
PCL2 I did not struggle to find the product.	
PCL3 The route to find the product is well designed to lead me to a specific product.	
PCL4 Learning to operate the site interface is easy.	
PCL5 Finding a product is always straightforward.	
[Task Support Satisfaction]	
TKSAT. Task Support Satisfaction	(Garrity and Sanders, 1994)
TKSAT1 This Web site is more useful than I had expected.	
TKSAT2 Using this Web site enables me to accomplish tasks more quickly	
TKSAT3 This Web site makes it easier to do my task.	
[Self-Efficacy]	
TSE. Task Self-efficacy	(Phillips & Gully, 1997)
TSE1 I feel confident in my ability to search and locate the product in the same Website next time.	
TSE2 I think that I can eventually search and locate a product satisfactorily in this Website.	
TSE3 I feel that I am as capable of finding a product in this Website as well as other students.	
TSE4 I would have to search a product for a long time to be able to find one in this Website.	
CSE. Computer Self-efficacy	(Venkatesh et al. 2003)
CSE1: If there was no one around to tell me what to do as I go.	
CSE2: If I could call someone for help if I got stuck.	
CSE3: If I had a lot of time to complete the job for which the Website was provided.	
CSE4: If I had just the built-in help facility for assistance.	

Table 5-1 Sample Characteristics

Age

	Frequency	Percent
< 20	11	5.5
20 - 24	166	83
25 - 29	16	8
30 - 34	3	1.5
35 - 39	1	0.5
40 - 44	3	1.5
>45	0	0
Total	200	100

Gender

	Gender	
	Frequency	Percent
Male	122	61
Female	78	39
Total	200	100

Experience

	OWNDG		TRYBUY		VSTWEB	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	122	61	131	65.5	162	81
No	78	39	69	34.5	38	19
Total	200	100	200	100	200	100

OWNDG: Ownership of digital camera
TRYBUY: Chance to search information about digital camera
VSTWEB: Chance to visit Websites selling digital camera

Table 5-2 Descriptive Statistics

Construct	Mean	Std. Deviation
Browsing Time (BT)	258.965	193.969
Pages per View (PV)	11.480	10.042
Browsing Time per Page Viewed (BTP)	29.411	46.956
Last Time Own Digital Camera (OWNTM)	4.803	1.296
Last time to try to purchase product (TRYTM)	3.664	1.455
Expertise on product (EXPRT)	3.630	1.488
Last time to visit the website (VSTTM)	3.340	1.496
Interface Support Satisfaction (IFSAT)	4.763	1.415
Procedural Knowledge (PCL)	4.509	1.632
Download Delay (DNDLY)	5.543	1.386
Navigation (NVGN)	4.868	1.379
Better Than the Best Website Interface (BESTIF)	3.070	1.691
Sufficient Knowledge Provision (SUFF)	5.010	1.486
Better than Average Website Interface (AVG)	4.200	1.547
Declarative Knowledge (DCL)	4.008	1.209
Task Support Satisfaction (TKSAT)	4.788	1.495
Task Self-Efficacy (TSE)	5.302	1.417
Computer Self-Efficacy (CSE)	5.344	1.370

Notes: All constructs except BT, PV, BTP, OWNTM, TRYTM, EXPRT, VSTTM, and DCL are seven-point scales with the anchors 1 = Strongly disagree, 4 = Neutral, 7 = Strongly agree. The other scales are presented in Appendix.

Table 5-3 Inter-Construct Correlations

	Composite Reliability (# of items)	IFSAT	DNDLY	NVGN	PCL	TSE	CSE	DCL	TKSAT
IFSAT	0.934 (4)	0.884							
DNDLY	0.946 (2)	0.557	0.948						
NVGN	0.886 (2)	0.720	0.573	0.892					
PCL	0.917 (4)	0.713	0.518	0.730	0.857				
TSE	0.913 (3)	0.624	0.512	0.656	0.538	0.887			
CSE	0.917 (4)	0.465	0.393	0.556	0.470	0.738	0.857		
DCL	1.000 (1)	0.049	0.060	0.131	0.075	0.121	0.078	1.000	
TKSAT	0.946 (3)	0.608	0.446	0.692	0.564	0.722	0.615	-0.043	0.924

Note. 1. Composite Reliability = CR = $(\sum\lambda_i)^2 / [(\sum\lambda_i)^2 + \sum_i var(\epsilon_i)]$, where : λ_i is the component loading to an indicator and $var(\epsilon_i) = 1 - \lambda_i^2$

2. The numbers on the leading diagonal are the square root of the variance shared between the constructs and their measures (AVE= $\sum\lambda_i^2 / [\sum\lambda_i^2 + \sum_i var(\epsilon_i)]$). Off diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be larger than off-diagonal elements.

3. The acronyms are: IFSAT (interface support satisfaction), DNDLY (download delay), NVGN (navigation), PCL (procedural knowledge), TSE (task self-efficacy), CSE (computer self-efficacy), DCL (declarative knowledge), TKSAT (task support satisfaction).

Table 5-4 PLS Outer Model Loadings

Internal Consistency Reliability and Factor Loadings of Measurement Items in Substantive Model*

Construct and items	Factor loading	Composite scale reliability	Average variance extracted
IFSAT			
IFSAT1	0.859	0.934	0.781
IFSAT2	0.868		
IFSAT3	0.921		
IFSAT4	0.886		
DNDLY			
DNDLY1	0.956	0.946	0.898
DNDLY2	0.940		
NVGN			
NVGN4	0.909	0.886	0.796
NVGN1	0.875		
PCL			
PCL1	0.840	0.917	0.735
PCL2	0.878		
PCL3	0.898		
PCL5	0.813		
TSE			
TSE1	0.882	0.917	0.787
TSE2	0.874		
TSE3	0.889		
CSE			
CSE1	0.856	0.917	0.734
CSE2	0.856		
CSE3	0.906		
CSE4	0.807		
TKSAT			
TKSAT1	0.911	0.946	0.854
TKSAT2	0.921		
TKSAT3	0.939		
DCL			
DCL1235	1.000	1.000	1.000
EXPRT			
EXPRT	1.000	1.000	1.000

* All loadings are significant at less than .001 (one-tailed tests).

Note. The acronyms are: IFSAT (interface support satisfaction), DNDLY (download delay), NVGN (navigation), PCL (procedural knowledge), TSE (task self-efficacy), CSE (computer self-efficacy), DCL (declarative knowledge), TKSAT (task support satisfaction), EXPRT (expertise on products).

Table 5-5 Means and Standard Deviations of Dependent Variables

	CAT	GD	Mean	Std. Deviation	N
BTP	Low	Low	28.118	39.592	44
		High	37.875	77.376	43
		Total	32.940	61.088	87
	High	Low	30.245	39.177	43
		High	22.659	12.824	50
		Total	26.166	28.333	93
SUFF	Low	Low	5.020	1.355	44
		High	5.140	1.441	43
		Total	5.080	1.391	87
	High	Low	4.930	1.791	43
		High	5.220	1.282	50
		Total	5.090	1.537	93
AVG	Low	Low	3.860	1.374	44
		High	4.530	1.202	43
		Total	4.200	1.328	87
	High	Low	4.160	1.758	43
		High	4.680	1.449	50
		Total	4.440	1.612	93
DCL	Low	Low	4.116	1.254	44
		High	4.072	1.046	43
		Total	4.094	1.150	87
	High	Low	3.656	1.450	43
		High	4.082	1.115	50
		Total	3.885	1.291	93
PCL	Low	Low	3.994	1.667	44
		High	4.924	1.628	43
		Total	4.454	1.704	87
	High	Low	4.436	1.776	43
		High	4.925	1.301	50
		Total	4.699	1.550	93

Note. Acronyms are procedural knowledge acquisition (PCL), declarative knowledge acquisition of product (DCL), number of pages viewed during the task (BTP), sufficient knowledge regarding digital cameras (SUFF), interface design better than that of other average websites (AVG).

Table 5-6 Multivariate Test of Significance

Effect	Wilk's Lambda	F	Hypothesis df	Error df	Sig.
Breadth	0.977	0.814	5	172	0.541
Depth	0.925	2.806	5	172	0.018
Breadth *Depth	0.975	0.881	5	172	0.495

Table 5-7 Univariate Tests of Significance: Between Subject Variables

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	BTP	5463.437	3	1821.146	0.819	0.485
	SUFF	2.239	3	0.746	0.344	0.793
	AVG	18.691	3	6.230	2.927	0.035
	DCL	6.210	3	2.070	1.386	0.249
	PCL	27.036	3	9.012	3.554	0.016
Intercept	BTP	158410.606	1	158410.606	71.235	0.000
	SUFF	4623.516	1	4623.516	2132.938	0.000
	AVG	3331.090	1	3331.090	1564.978	0.000
	DCL	2842.164	1	2842.164	1903.390	0.000
	PCL	3744.449	1	3744.449	1476.651	0.000
Breadth	BTP	1919.896	1	1919.896	0.863	0.354
	SUFF	0.002	1	0.002	0.001	0.978
	AVG	2.212	1	2.212	1.039	0.309
	DCL	2.271	1	2.271	1.521	0.219
	PCL	2.192	1	2.192	0.865	0.354
Depth	BTP	52.833	1	52.833	0.024	0.878
	SUFF	1.852	1	1.852	0.855	0.357
	AVG	15.828	1	15.828	7.436	0.007
	DCL	1.638	1	1.638	1.097	0.296
	PCL	22.565	1	22.565	8.899	0.003
Breadth*Depth	BTP	3370.562	1	3370.562	1.516	0.220
	SUFF	0.335	1	0.335	0.155	0.695
	AVG	0.266	1	0.266	0.125	0.724
	DCL	2.475	1	2.475	1.658	0.200
	PCL	2.181	1	2.181	0.860	0.355
Error	BTP	391382.327	176	2223.763		
	SUFF	381.511	176	2.168		
	AVG	374.620	176	2.129		
	DCL	262.805	176	1.493		
	PCL	446.296	176	2.536		
Total	BTP	552858.998	180			
	SUFF	5035.000	180			
	AVG	3756.000	180			
	DCL	3129.050	180			
	PCL	4250.000	180			
Corrected Total	BTP	396845.764	179			
	SUFF	383.750	179			
	AVG	393.311	179			
	DCL	269.015	179			
	PCL	473.332	179			

Note. Acronyms are procedural knowledge acquisition (PCL), declarative knowledge acquisition of product (DCL), number of pages viewed during the task (BTP), sufficient knowledge regarding digital cameras (SUFF), interface design better than that of other average websites (AVG).

Table 5-8 Depth * Success Crosstabulation

		Success		Total	Chi-Square	
		Failed	Succeeded		Value	Significance
Depth	High	18	74	92	25.252	0.000
	Low	51	41	92		
Total		69	115	184		

Table 5-9 Breadth * Success Crosstabulation

		Success		Total	Chi-Square	
		Failed	Succeeded		Value	Significance
Breadth	High	25	71	96	11.244	0.001
	Low	44	44	88		
Total		69	115	184		

Table 6-1 Summary of Hypotheses Testing

Hypothesis (PLS model)	Support (DV: Analysis Method)
H1a. As the number of categories and features of product increases (high level of breadth), the declarative activation will decrease.	Not Supported (DCL: MANOVA)
H1b. As an interface guides the customer to locate the product better, customers achieve production compilation more effectively.	Supported (S: Chi-Square test) Supported (PCL: MANOVA) Supported (AVG: MANOVA) Not Supported (BTP: MANOVA)
H1c. As breadth increases, long-term declarative knowledge also increases.	Supported (S: Chi-Square test) Not Supported (DCL, SUFF: MANOVA) Control: EXPRT (significant): PLS
H2a. Interface Satisfaction will enhance declarative knowledge acquisition. (IFSAT->DCL)	Not Supported (DCL: PLS)
H2b: Interface Satisfaction will enhance procedural knowledge. (IFSAT->PCL)	Supported (PCL: PLS)
H2c: Website Download Delay will be negatively related with procedural knowledge. (DNDLY->PCL)	Not Supported (PCL: PLS)
H2d: Navigation effectiveness will be positively related to procedural knowledge. (NVGN->PCL)	Supported (PCL: PLS)
H3a. An increase in declarative knowledge acquired during task performance will increase affective learning outcome, task self-efficacy. (DCL->TSE)	Not Supported (TSE: PLS)
H3b. Fast compilation will enhance computer self-efficacy. (PCL->CSE)	Supported (CSE: PLS)
H4a. Enhanced long-term declarative knowledge will make you perceive the Web information system to	Not Supported (TKSAT: PLS) Control: EXPRT (significant)
H4b: The enhanced procedural knowledge will positively affect Task Support Satisfaction. (PCL->TKSAT)	Supported (TKSAT: PLS)

Note. Acronyms are procedural knowledge acquisition (PCL), declarative knowledge acquisition of product (DCL), number of pages viewed during the task (BTP), sufficient knowledge regarding digital cameras (SUFF), interface design better than that of other average websites (AVG), IFSAT (interface support satisfaction), DNDLY (download delay), NVGN (navigation), PCL (procedural knowledge), TSE (task self-efficacy), CSE (computer self-efficacy), TKSAT (task support satisfaction), EXPRT (expertise on products), DV (dependent variable), PLS (partial least square). Statistical significance of support level is 5%.

Figure 3-1 Research Model

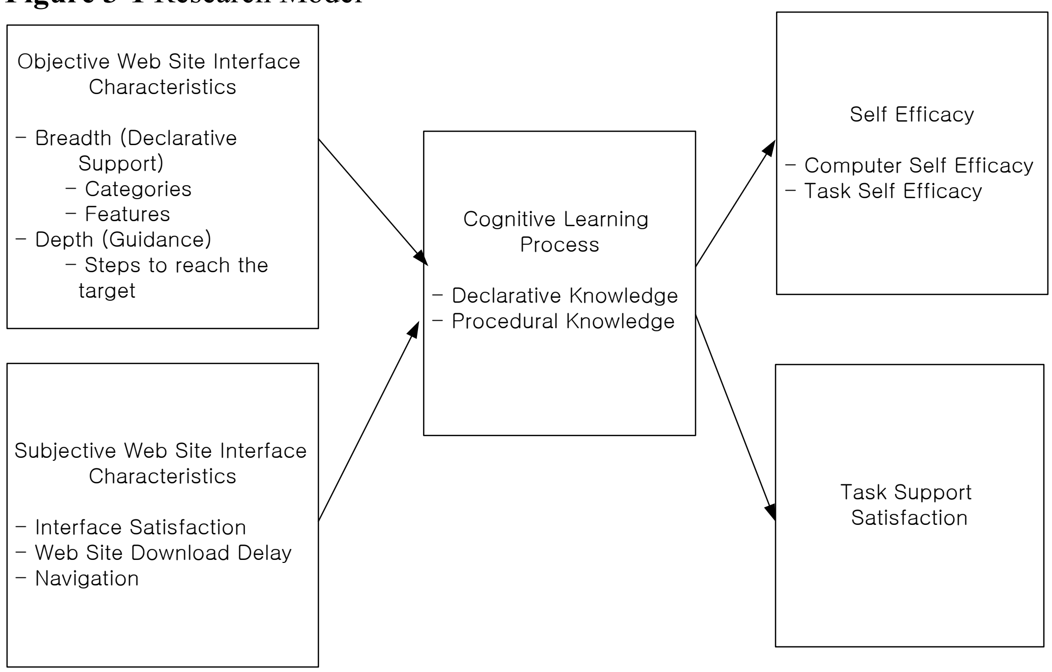
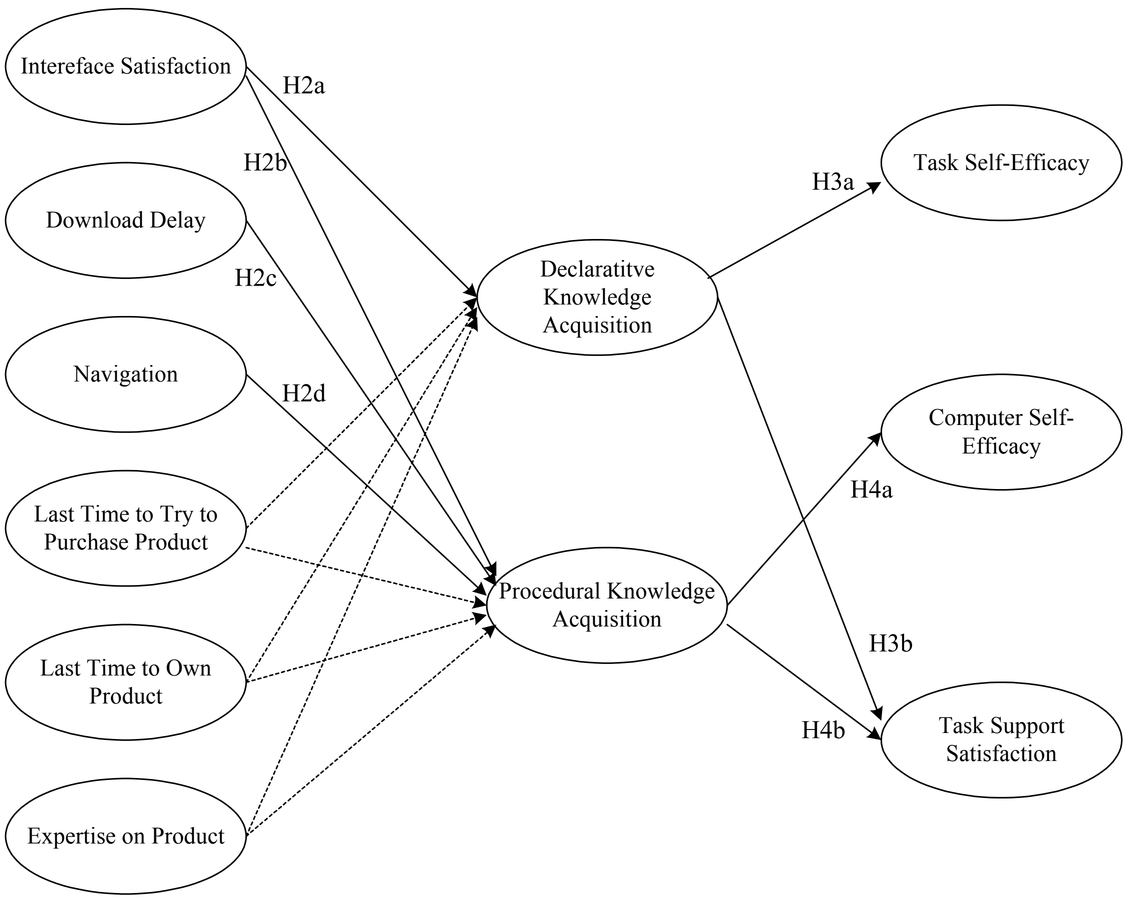


Figure 3-3 Hypothesized Research Model



Note. Constructs with dotted arrow are control variables.

Figure 4-1 The combination of interface components

Depth of Categories \ Breadth of Categories	Low	High
Low	1	2
High	3	4

Figure 4-2 Four interface designs

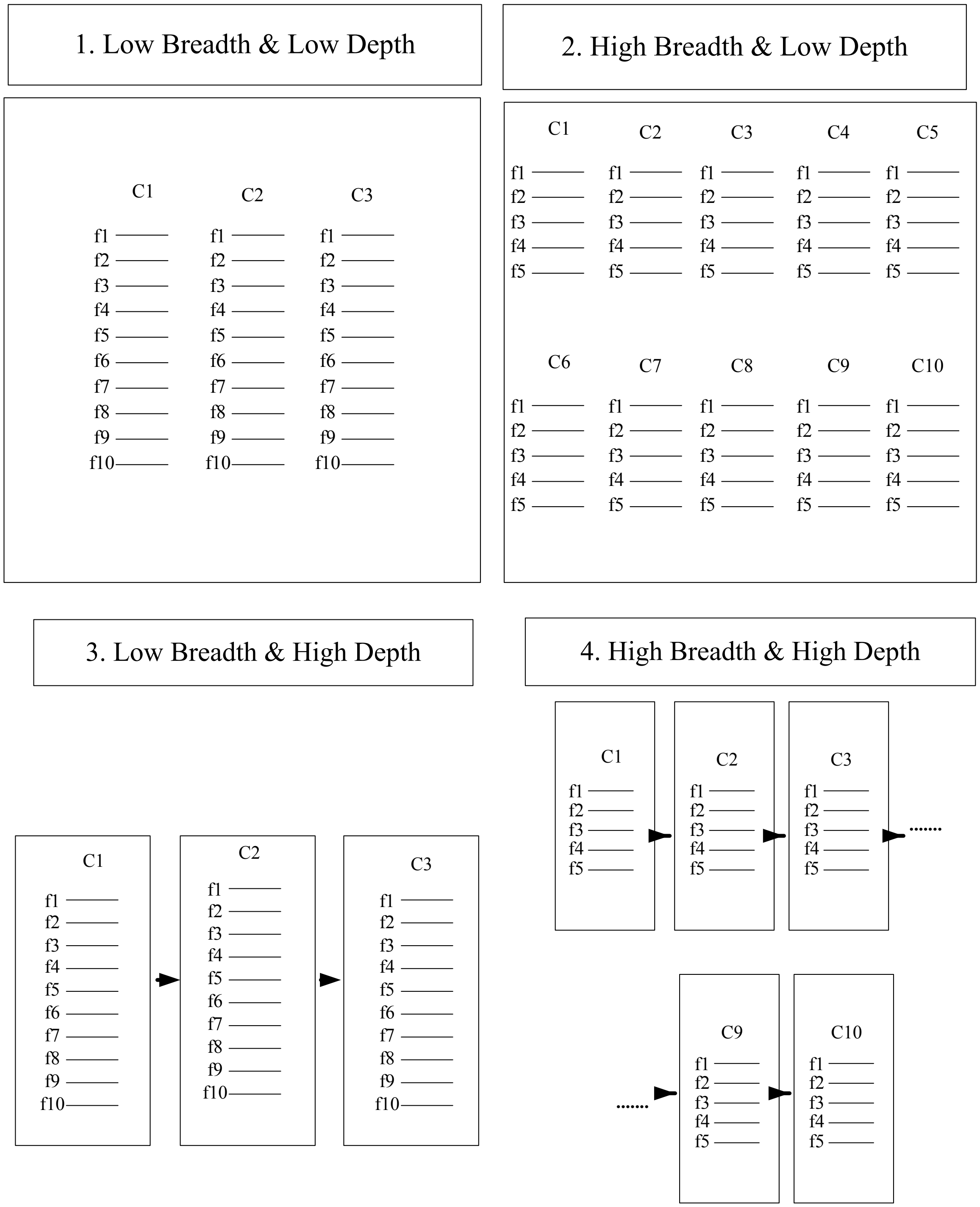
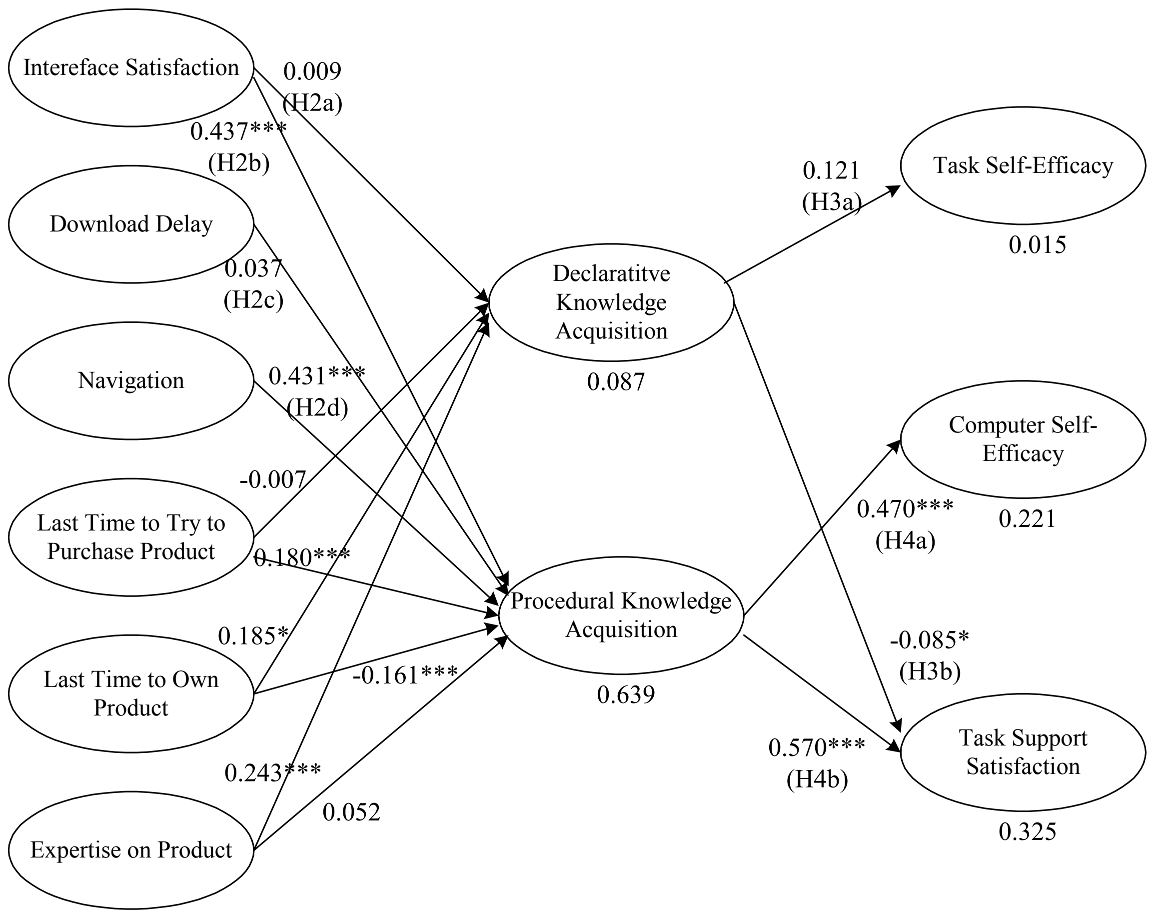


Figure 5-1 Partial Least Square Results



* p<.10
** p<.05

*** p<.001

APPENDIX 2

SCALES AND ITEMS

[Demographics]

1. What is your age?
2. What is your gender? Male Female
3. Have you ever owned a digital camera? If yes, when? (Conditional) Yes No
    a. When did you buy a digital camera?
        i. This week
        ii. 1 month ago
        iii. 3 months ago
        iv. 6 months ago
        v. 1 year ago
        vi. 2 years ago
        vii. More than 2 years

4. Have you ever tried to buy a digital camera and searched information about digital cameras? (Conditional)
    a. If yes, when?
        i. This week
        ii. 1 month ago
        iii. 3 months ago
        iv. 6 months ago
        v. 1 year ago
        vi. 2 years ago
        vii. More than 2 years

5. How much do you know about digital cameras? 1 2 3 4 5 6 7
6. Have you ever visited this website?
    a. If yes, when?
        i. This week
        ii. 1 month ago
        iii. 3 months ago
        iv. 6 months ago
        v. 1 year ago
        vi. 2 years ago
        vii. More than 2 years

7. Have you ever visited an electronic commerce website that sells digital cameras?
    a. If yes, when?
        i. This week
        ii. 1 month ago
        iii. 3 months ago
        iv. 6 months ago
        v. 1 year ago
        vi. 2 years ago
        vii. More than 2 years

[Subjective Website Interface Characteristics]

Interface Quality Satisfaction (Garrity and Sanders)

IFSAT1. I like using the interface of this website.
IFSAT2. This website has all the functions and capabilities I expect it to have.
IFSAT3. This website is user-friendly.
IFSAT4. This website is easy to navigate.

Website Download Delay (Palmer 2002)

DNDLY1. The speed at which the website provided information was fast.
DNDLY2. The rate at which the information was displayed was fast.

Navigation (Palmer 2002)

NVGN1. The sequence of obtaining information was clear.
NVGN2. The layout of pages made tasks easier.

[Cognitive Learning Process]

Declarative Knowledge of product

DCL1. What does the value and unit "4 mega-pixels (or 4M)" best represent?

a. Flash type
b. Resolution
c. Memory storage
d. LCD display
e. Optical zoom

DCL2. To which category does "SD/MMC card" belong?

f. Flash type
g. Resolution
h. Memory storage
i. LCD display
j. Optical zoom

DCL3. What does the value and unit "3X" best represent?

k. Flash type
l. Resolution
m. Memory storage
n. LCD display
o. Optical zoom

DCL4. What is the correct explanation of "camera resolution"? If you do not know the exact answer, please choose your best guess.

p. For digital cameras, the resolution usually is expressed as a matrix of horizontal by vertical pixels.
q. Resolution is the number of images (pictures) that can be stored, depending on the image quality mode.
r. Resolution is a standardized image compression format developed by the Joint Photographic Experts Group.

s. Resolution is a brief, intense burst of light, usually used where the lighting on the scene is inadequate for picture taking.
t. With resolution, a subject or image is viewed through a small screen, ranging between 1.8 and 2.5 inches in diameter.

Procedural Knowledge

PCL1. I am satisfied with the speed I found the product.
PCL2. I did not struggle to find the product.
PCL3. The route to find the product is well designed to lead me to a specific product.
PCL4. Finding a product always is straightforward.

[Web Information Systems Acceptance]

[Task Support Satisfaction]

TKSAT1. This website is more useful than I had expected.
TKSAT2. Using this website enables me to accomplish tasks more quickly.
TKSAT3. This website makes it easier to do my task.

[Self-Efficacy]

Task Self-Efficacy (Phillips & Gully, 1997)

TSE1. I feel confident in my ability to search and locate products on the same website next time.
TSE2. I think I eventually can search and locate a product satisfactorily on this website.
TSE3. I feel I am as capable as other students of finding a product on this website.

Computer Self-Efficacy (Venkatesh et al. 2003)
CSE1. I have the ability to find a specific digital camera on this website.
CSE2. I have the ability to obtain information on digital cameras on this website.
CSE3. I have the ability to find a digital camera that I want to buy on this website.
CSE4. I have the ability to find a digital camera with a certain specification on this website.

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