December 2002

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Abstract

E-commerce systems (ECS) are Web-based systems that perform various stages of an e-commerce transaction. ECS typically include sub-systems such as electronic catalogs, shopping-cart systems, payment systems, order-tracking systems, merchandise return systems, customer service systems, and other e-commerce functions. Similar to conventional information systems, system usability is an important issue for ECS. For developers, usability guidelines or principles are essential for improving user interfaces, system designs, and functionality of the system. However, most existing usability studies were conducted on different computing platforms. The results may not be applicable to ECS unconditionally. This paper is a research in progress that examines the usability issues of ECS. It first reviews and classifies existing studies related to system usability in the past few decades. The applicability of findings from existing studies is examined and discussed. Finally, a research taxonomy for measuring and improving the usability of ECS is proposed.

ECS Usability

Information system usability covers issues related to users and tasks performance. Researchers in academia and practitioners in industries have adopted different approaches to assess system usability. For example, many practitioners rate system usability using objective measures such as systems response time, task completion time, and error rates (Moon and Kim, 2001). Academic researchers pay more attention to subjective measures such as perceived ease of use, perceived usefulness, and self-reported user satisfaction. Both types of studies provide valuable insights and useful assessment of usability. Study results from both sides are found to be correlated to each other (Nielsen, 1994). In other words, subjective measures and objective measures work equally effective for assessing system usability.

Usability is an important issue for ECS due to many reasons. First, users of ECS often are located in remote locations. It is more difficult for ECS users to get hands-on help from technical support personnel. Second, the Web is an open and connected environment. Switching from systems to systems is easy. Users are more likely to abandon a low-usability system in favor of a more usable one. To ensure users stay on the system till the transaction is completed, usability is a key factor. Third, users of ECS are diverse. The backgrounds and experiences of users are more difficult to predict. The system needs to be designed to accommodate all sorts of users. Fourth, ECS are the online presence for companies. A low usability system reflects a poor image of the company. Fifth, ECS often can process transactions at a lower cost than other alternatives. Low usability ECS might drive users to the high-cost alternatives such as using tool-free numbers or obtaining face-to-face services. Sixth, unlike traditional systems, users of ECS are typically not trained before they use the system. It is not realistic to expect them to interact with the systems using efficient methods, such as constructing the right query to retrieve information (Rocchio, 1971). Finally, users of ECS sometimes don't know what they are looking for, or not sure if the system can solve their problems or not (Belkin, 2000). This additional dimension of uncertainty makes a usable system even more important.

Challenges of ECS Usability

Developing a usable ECS is not an easy task. Many factors make the development of usable ECS challenging. First, there is not a well-defined set of usability principles available. Results from existing studies are neither sufficient nor conclusive (Nelsen,

1999). Most of them provide only vague principles of good usability. Second, the concept of usability is subjective as well as scientific. On the subjective side, usability experts and researchers often hold different views on what make a system usable. There is a lack of hard evidence to resolve the conflicting opinions. In addition, usability partially depends on user experiences. Achieving usability requires a user-centered design process that has cultural, strategic, and technical implications (Bevan, 1999). Since Web users are highly diverse in terms of their computing experiences, it would not be easy to design systems that satisfy users. Third, usability is dependent on the computing environment. With the Internet being an open and heterogeneous computing environment, users may use very different hardware and software combinations than the developers. Many traditional usability concepts, such as WYSIWYG, simply do not apply well for ECS. For example, users may use many different devices with a variety of screens and sizes to access ECS. In addition, there are variations in resolutions, bandwidths, browsers, security settings, and many others. A usable ECS must be designed so that the majority of users will be able to view the system properly regardless of the platforms used (Nielsen, 1999).

Usability Study for Traditional Systems

Usability is about ensuring a successful system from users' perspective. A system that perfectly matches technical specifications may not possess good usability. Usability is difficult to achieve, because it normally does not have a clearly defined set of objectives (Dzida, 1996). In general, the goal of usability efforts is to improve interactive systems and their user interface. The targets for improvement are many, including user productivity, task effectiveness, interface aesthetics, and many others.

In this study, usability is defined as the ability of an interactive system to assist users and tasks. The focus is on user and task issues related to ECS. Based on this definition, a 2*2 matrix is used as the framework to summarize past research efforts on system usability (Table 1.)

Table 1. Classification of Existing Usability Studies

Target of Measurement / Measuring Methods	Tasks	Users
Objective measures (observations)	Category I: Task completion time, Throughput, etc.	Category II: Usage frequency, online time Ergonomic impacts: visual, audio, motor impacts, etc. Retention of information
Subjective measures (self-reporting questionnaires)	Category III: Decision-making quality, Product quality (e.g. CAD systems), Service quality (e.g. help desk systems), etc.	Category IV: Enjoyment, playfulness (intrinsic) Familiarity (intuitiveness) Intention to use Aesthetic: perceived attractiveness of the system design

The vertical dimension of the matrix is the method of data collection. The two categories for this dimension are subjective and objective data colleting methods. The horizontal dimension is the target of measurement: tasks or users. Using this framework, usability studies are organized into four categories. Category I studies use objective measures to study the impact of system usability on tasks. An example would be a study that measures task completion time using a particular system. Category II studies use objective instruments to measure the effects of system usability on users. Studies in this category include the impacts of systems on users' visual and auditory sensors, short-term and long-term retention of information, learning effectiveness, or even impacts on muscles, eyes, and others. Category III studies use subjective methods to collect information on task performance. An example would be a study that asks a group of subjects to assess the quality of decisions made with the help of decision-support system. The subjects are not necessarily direct users. They could also be people affected by the decisions. Category IV studies use subjective measures to examine user opinions toward systems. Data collected by studies in this category are perceptual in nature. User satisfaction studies fall into this category. Details of studies in each category and the usability principles derived will be discussed in the full paper.

Applicability of Existing Usability Research to ECS

Although there is a significant amount of research efforts devoted to usability studies, not all the results from existing studies may apply to ECS. In this section, we examine the applicability of existing usability research outcomes to ECS.

Graphics vs. Text Issues

A recent survey shows that graphics are used only minimally on Web-based systems (Huang 2002). The survey analyzes fifty Web-based systems of major corporations. The result shows that the majority of the systems are text-based, rather than graphics. Graphics are used, but only on a limited basis. Most of the ECS cleverly use fonts, tables, and colors to make its interface more interesting and attractive, without using a great deal of graphics. No hard evidences are found to explain the phenomena. However, several possible factors might provide some insights.

The first factor is the limited screen space available for ECS. Unlike stand-alone or client-server based systems where users tend to be captive audience, ECS users are normally free to switch from systems to systems. Besides, the Web is a multi-functional network that incorporates both work and pleasure-oriented systems on one platform (Moon and Kim, 2001). Abundance of distractions are constantly present. Consequently, ECS are constantly combating for user attention. The use of graphics increases the need for space, and consequently more layers of pages are needed to convey information. Increase in layers and pages raises the risk of losing user attention. Users are often impatient, and often don't know what they are looking for or not sure whether the information is on the system or not (Belkin, 2000). They might quickly lost interest if it takes too long and too much effort to use the system.

The second issue is response time. Unlike stand-alone systems that store information locally, ECS access information stored in remote locations. Unlike client-server based systems that use high-speed local area networks, ECS rely on relatively smaller bandwidth on wide area networks. The majority of Web users today still rely on dial-up connections with a V.90 modem. The download speed is limited to 56 kbps, and the actual speed is often less than half of the maximum speed. Users with high-speed connections are still minority. Thus, excessive use of graphics would certainly increase the download and response time. Response time is more important for ECS than stand-alone or client-server systems. On the Web, uses are often impatient to wait for long downloads. Switching to another system is only a few keystrokes away. It will not be wise to use excessive graphics at the cost of response time.

The third issue is control. From a technical perspective, it is more difficult to control the size and proportion of graphics on the Web client. Graphics are usually displayed based on pixels. Original images that occupy only one quarter of a screen might take up the entire screen space making the page impossible to read. If the image is configured to resize itself according to screen size (i.e., images displayed relative to screen size), the resized images usually are not as good as the originals. On traditional client-server systems, the client workstations usually follow a tighter restriction on both software and hardware. Thus, the appearance of graphics can be controlled. For ECS, users may use a wide variety of operating systems and hardware. As a result, graphics may display at different proportion on client devices.

Cognitive-Fit Issues

Based on the cognitive-fit theories, interactive systems that provide information using formats appropriate for tasks and user cognitive styles are more effective. Similar claims have been made and discussed by other researchers. In reality, such theories are rarely adopted and implemented on information systems. Systems are normally designed to perform and optimize a specific task. Users usually may only adjust the system on minor interface setting to meet personal preferences. Another possible reason for not adopting the cognitive-fit theory is lack of competition and alternatives. In the conventional computing environment, users are often forced to use systems selected by the employers or system administrators. Sometimes, a system with a dominant market share gives users no choice but using it. Consequently, there is no strong incentive for vendors to produce systems that consider user cognitive styles.

Contrary to conventional systems, ECS operate under very different environment. The Internet is an open network. Users may change from systems to systems with little or no switching cost till they find systems that suit their styles and preferences. In other words, ECS face more competition from comparable ECS. Consequently, an interface that meets users preferences is important to retain users. As a result, many systems with a large number of target users provide customizable interfaces. Popular systems

such as Yahoo, MSN, and numerous other ECS provide their users individualized pages. Web-based financial systems normally allow users to select data presented in either tabular formats or graphical formats, based on their preferences and tasks. Customizable ECS represent a significant change of systems design. Instead of providing users information presented using a pre-designed standard interface, such systems provide a selection of information and a framework. Users decide what they want and how they want it to be displayed.

Unique or Important Issues for ECS Usability

Response Time

System response time has been a subject of research for decades. It has been linked to productivity, user satisfaction, and state anxiety (Guynes, 1989). For traditional client-server systems, user workstations typically are connected through LAN, private leased lines, WAN, or other high-speed lines with quality-of-service guarantees. On such types of networks, system response time is normally a function of database design (Cheng, Goh, and Lee-Post, 1999), distributed computing structure (Stefano, Bello, & Tramontana, 1999), data types, network traffic, and other factors. Most of these factors are controllable by design or hardware improvement.

The architecture of ECS is different from client-server based systems. The cores of ECS are located on servers in remote locations from user workstations. In most cases, the majority of computing is done on the server side. The browser end performs only limited processing, except for information presentation. Furthermore, the server side of the ECS normally has little control over the client devices or network traffics. Thus, any bottleneck between the server and the browser might delay the response time of the system (Rodriguez & Biersack, 1998). Since the Internet currently have no quality-of-service guarantee, significant delay could occur. Besides, the initial fascination with the Web has diminished. Users are becoming more demanding on quality and speed of the systems. As a result, response time could become a significant factor for system use.

Security/Privacy Issues

Security is especially important for ECS, due to the open nature of the Internet. Many ECS process confidential or personal information, such as social security numbers, credit card information, medical information, and so on. Due to the growing concern of identity thieves, users may not use a system they perceive as insecure despite its ease of use and usefulness. An insecure system might be seen as unusable.

Research Taxonomy for ECS Usability

Using the existing usability studies in IS research as a foundation, a research taxonomy for ECS usability is developed. The taxonomy continues to use users and task as the two main categories, because usability is about users and tasks (See Table 2).

Future Plan to Complete the Study

The study is currently in progress. Future efforts are needed to complete the following tasks:

1. Refine the taxonomy using an expert panel
2. Map existing ECS studies into the taxonomy
3. Identify areas needed more research efforts.

Table 2. ECS Research Taxonomy

Subject of the Study	Measurement Methods	Research Topics
Users	Objective observations/measurements	• Learning curves: how long does it take for a user to learn an ECS? • Usage frequency of ECS: do users use the site frequently? • Stickiness/user retention • Average online time: do users use the site for a long period of time?
	Subjective responses	• Enjoyment, playfulness: do users think the system is fun to use? • Familiarity of ECS interface (intuitiveness): Are the interface familiar to users? • Intention to use ECS: Do users intend to use the ECS (again?) • Aesthetic: Do users perceive the system as attractive? • Trust: do users perceive the system as trustworthy or from a legitimate source? • Security: do users perceive the system as secure? • Privacy: do users believe their privacy will be protected? • Do users feel tired? • Do users feel irritated? • Are users confused, or lost? • Are users overloaded with information? • Information quality issues • Multimedia use, layouts, etc.
Tasks	Objective observations/measurements	• Probability to find information looked for • Transaction completion time • Transaction completion rate (%) • System response time • Transaction processing throughput • How many links does it take to reach the target information?
	Subjective responses toward task	• Are users satisfied with the task quality? • Are users satisfied with the service quality? • Do users feel the task is completed smoothly? • Do users feel the system save them time?

References

Available upon request.