CENTER for ADVANCED INFORMATION MANAGEMENT

a New York State Center for Advanced Technology at Columbia University

Technology Fact Sheet

Design and Evaluation of Health Information Technologies

The Problem

Technology is increasingly playing a central role in medical practice and biomedical research, but there is often a gap between technologies and end-users. Bridging this gap necessitates both changes in the design of artifacts and the development and refinement of human competencies. One challenge in deploying health-related technologies is fashioning systems that are readily usable by the end users. The consequences of improper system design and evaluation can range from end-user frustration to the compromise of patient safety. The recognition that even superior system design can often result in significant usability problems has heightened the importance of conducting rigorous evaluation at all phases of design, and implementation.

Cognitive and social sciences provide a framework for analysis and modeling of complex human performance. They can also provide insight into principles of system usability, the process of medical judgment and decision-making, the training of health-care and biomedical personnel and end-users, as well as the study of collaboration in the workplace. Iterative design, guided by cognitive usability evaluation, can contribute significantly to improving the quality of technology and thereby enhance the value and marketability of a product.

The Solution

The Laboratory of Decision Making and Cognition (LDMC) at Columbia University has developed methods for evaluating health-related technologies that can be used to improve the design of biomedical systems. The evaluation can be adapted to different phases of product design from early system prototypes and design mockups to fully implemented systems. Using these tools, we have evaluated a range of medical devices such as infusion pumps and glucose monitoring systems, and various information technologies such as electronic medical records, physician order-entry systems, tutorial systems, bibliographic retrieval systems, and web-based virtual clinics. The evaluation methods are based on a broad cognitive foundation that incorporates theories from human-computer interaction, human factors research, distributed cognition, and naturalistic decision making. Our methods have been refined through extensive experience and work with a host of technologies.

The Approach

The approach includes three classes of evaluation techniques:

1. *Usability inspection* is a comparatively low cost approach that evaluates the system functionality by human-computer interaction specialists. We use -
   - *Heuristic evaluation.* An easy-to-use method that focuses on how to identify major usability problems of a software product or device in a timely manner and with reasonable cost.
   - Cognitive task analysis, including the *cognitive walkthrough*, involves identifying sequences of actions and goals needed to accomplish a given task, and potential problems that may impede the successful completion of the task.
2. In *usability testing,* participants who are representative of a target population are used to evaluate the degree to which a product or system satisfies basic criteria. It is regarded as perhaps the most informative test of a system's adequacy. Although usability testing is more commonly conducted in laboratory settings, we also engage in field-testing at clinical or research sites and in patient homes using portable usability laboratories. We have evolved innovative video-analytic techniques for studying user performance and characterizing usability problems.
3. *Workplace Analysis.* The implementation of any innovative technology needs an understanding of the work setting. The LDMC group has refined an approach to field studies that incorporates ethnographic methods, discourse analysis, and work analysis methods, including analysis of workflow. These techniques characterize the ebb and flow of work activity, differentiation of roles, patterns of communication, and the role of physical artifacts (e.g., paper documents) in task performance. An understanding of the workplace facilitates the implementation process and can be used to develop a targeted training program.

All usability evaluation is predicated on an in-depth understanding of the user target population. Our methods have been adapted to different classes of user populations including physicians, nurses, researchers, and other health-care and biomedical personnel. Within each group, there are individuals with different degrees of computer proficiency and domain expertise that need to be considered. We have also tailored our methods to e-health initiatives that target patient populations of varying degrees of computer and health literacy.

The methods we employ contribute substantively to iterative interface design. However, our work goes well beyond characterizations of the interface to focus on how technologies mediate performance on tasks ranging from therapeutic decision making by clinicians to patients monitoring and reviewing their own records. This also includes identification (and possible solutions) of medical and health-related errors.

Access to Technology
The staff of the Laboratory of Decision Making and Cognition (LDMC) at Columbia University is available for consultation and collaboration. See http://www.dbmi.columbia.edu/patel/LDMC_pages/LDMC and contacts below.

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The Center for Advanced Information Management

Technology Overview
The Center for Advanced Technology Information Management at Columbia University is a joint effort of the Department of Biomedical Informatics (Columbia University Medical Center), the Computer Science Department (School of Engineering, Columbia University), the Center for Computational Biology and Bioinformatics, and the bio-imaging group in the Biomedical Engineering Department (School of Engineering).

Biomedical Informatics deals with the storage, retrieval, sharing, and optimal use of biomedical information, data, and knowledge for problem solving and decision-making. It touches on all basic and applied fields in biomedical science, and is closely tied to modern information technologies, notably in the areas of computing and communications.

Researchers in the *Computer Science Department* study theoretical and experimental aspects of many areas of information management and technology - foundations in mathematics, optimization, hardware design, software design, networks, user interfaces, databases, communications, and artificial intelligence. In particular, the department has concentrated expertise in digital library technology, digital government systems, and novel visual and graphical interfaces for information management.

The *Center for Computational Biology and Bioinformatics* (C2B2), is an interdepartmental center whose goal is to catalyze research at the interface between biology and the computational and physical sciences. It encompasses the Columbia Genome Center and Center for Systems Biology. C2B2 supports research programs in computational biophysics and structural biology; modeling of regulatory, signaling and metabolic networks; pattern recognition; machine learning; and functional genomics.

The approach of the *Biomedical Imaging Lab* includes both basic science (e.g. image acquisition) and clinical applications (e.g. evaluation of image quality). BMIL's scope is broad, including image formation, qualitative analysis, evaluation and quantitative measures. Studies are aimed at imaging structures at the molecular, cellular, tissue, and organ levels.

CAT Mission
The goal of the Centers for Advanced Technology program is to support cutting-edge research at major New York State research institutions, and to make the resulting technology available to industry for commercialization. CATs work with industry partners in several ways to achieve this goal. Inquiries are welcomed.

The *Center for Advanced Information Management* at Columbia University is a NYSTAR Designated Center for Advanced Technology.