Measuring mental models: Rationales and instruments

Yan Zhang, Peiling Wang

School of Information Sciences, College of Communication and Information, The University of Tennessee, Knoxville, 1345 Circle Park, Knoxville, TN 37996-0341 Email: yzhang@utk.edu; peilingw@utk.edu

The purpose of this study is to develop and test an instrument for measuring users' mental models of Web search engines. Mental models play an important role in users' interactions with a system. Understanding users' mental models is important to the design of congruent interfaces.

Rationales of measuring mental models

In the field of human-computer interaction (HCI), research on mental models has produced a body of literature in the past twenty years. Despite differences in perspectives and terminologies surrounding mental models, the core of the topic concerns the understanding of the cognitive structures and processes underlying the behaviors of human beings performing computer based tasks. It is clear that interaction with a computer is often a subtask during the completion of some main tasks. The main tasks may include finding information, sending a message, producing a report, and testing a statistical hypothesis. In fact, some tasks can be done without a computer (but generally more efficiently with a computer software tool). Knowing nothing about system structure and mechanisms beyond the system's display could be frustrating when interacting with a computer system. End users must possess a mental representation of the system before they feel comfortable with it. In this article, *mental model* refers to users' conceptual/internal representation of the system. Mental models are incomplete, limited, naive (unscientific), unstable, fuzzy, but vitally important. Mental models enable users to interact with and learn by trial and error about systems. Our goal for understanding mental models is three-fold: (1) systems should help users build appropriate mental models by providing meaningful and context-sensitive clues. (2) we need to design congruent interfaces that can anticipate users' next moves in order to provide adequate support. (3) we need to develop learning tools to help users move from novice to advanced levels.

A theory on mental models needs to address three important questions: (1) what are the users' conceptual representations of a system? (2) How do users apply such representations in interactions with systems? (3) How do users derive mental models? The first question concerns the content and structure of the mental models: what concepts do the users know and how are they related? The second question concerns the use of mental models in taking actions during interactions to perform the main task. These actual actions can be attributed to the aspects of the mental models. The third question concerns the learning process through which users build and modify their mental models.

We postulate:

(1) Mental models are based on prior experiences with similar systems using analogy or metaphor. Users tend to use mental models of other systems in interactions with a computer system.

(2) There are gaps between users' mental models and a system's conceptual model. A system has an underlying conceptual model that is often hidden from its users.

(3) There are gaps between the system's conceptual model and its user views or external models. We use user views to mean what Norman (1983) referred to as "system image", which is presented to the users as the implementation of the conceptual model. There are often more than one user views targeting different user groups. Typically, one for novices and one for advanced users.

In empirical studies of mental models, a majority adopt the strategy to measure users' mental models by measuring their task performances. Users with better mental models perform better in tasks. However, tasks assigned by the researchers may not measure all aspects of mental models. In this study, we propose an alternative approach to study mental models. We aim to develop an instrument to measure users' mental models of the Web. We are interested in the Web because it is the first-stop or the only place for many users in finding information. For more and more end users, this is the first IR system they learn. Their mental models of the Web will likely affect their behaviors when using other types of IR systems.

Instrument development

We are designing an instrument to measure users' general mental models of the Web as an IR system at a high (less detailed) level to address the first of the three research questions. We adopted the user-Web interaction model by Wang, Hawk, & Tenopir (2000) to develop the instrument with a focus on the following four components:

(1) The Web space (Web objects and collections)
(2) The Web's structure (organization of Web objects)
(3) The search functions (query algorithms; semantic and syntactic rules)
(4) The interface (navigation tools and access results)

The experience with the Web is assumed to affect users' mental models of the Web. To incorporate this factor, the instrument will solicit prior experience with the Web to identify its effects on mental models. The instrument will include questions corresponding to the following categories. The questions will be arranged randomly.

- *Experience*

This category measures users' prior experience with the Web. The indicators for user experiences include the length and frequency of use, the types of systems, the nature of the searches, and prior learning.

- *The Web space*

This category measures users' understanding of information objects on the Web and collections of objects accessible by a particular method. In this context, information object is regarded as the basic unit of the Web and may be in the form of text, image, flash, video, etc.

- *The Web's structure*

This category measures users' understanding of how information objects on the Web are organized for access. Factors that influence or shape the Web's structure as an IR system include hyperlinks, indexing and representing mechanisms, and Web search tools including search engines and classified directories.

- *The search functions*

This category measures users' knowledge of search engines' underlying logic, rules, and mechanisms (how the engine processes user input and generates output).

- *Interface*

This category measures users' understanding of general interface elements, including navigation tools and access results.

Currently the specific questions are being finalized. The actual instrument will be structured as a typical psychological instrument (inventory) including three types of questions: inclusive multiple choices, Likert-scale questions, and fill-in blanks. A subset of selected questions will each provide a reversed question to check reliability. The following are selected examples from each category:

- *Experience*

How did you originally learn to use the Web? (Choose all that apply)

a. I taught myself by reading
b. I taught myself by trial and error
c. I learned from a friend
d. I attended a training class/seminar/workshop
e. Other_____

- *The Web space*

All the information I need can be found through searching the Web.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree

All information on the Web is the most current.	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Information on the Web is free.	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
When I need information, my first choice is to ask a Web search engine.	Strongly agree	Agree	No opinion	Disagree	Strongly disagree

- *The Web's structure*

Search engines compare (index) every word on each Webpage to match my search input.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
On the Web all Web objects (Webpages, images, etc.) are linked.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree

If you would like to buy a CD by The Commitments

1. which Website would you use to find your CD? _____
2. write a search input you would enter at the Website _____

- *The search functions*

When I search a phrase, I put the phrase inside of quotation marks (" ").	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
The more words in a search input, the more in the output from the Web search engines.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
The more words in a search input, the less in the output from the Web search engines.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
Proper names need to be capitalized in search input.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree

- *Interface*

If I failed to find what I need on the Web, it is because my search strategy was not effective.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
If I cannot find what I need on the Web, I question about the adequateness of the search engine.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
I use BACK button to backtrack previously accessed pages.	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree
I truncate or modify URLs to get to an appropriate	Strongly agree	Agree	No opinion	Disagree	Strongly Disagree

Webpage.

Testing of the instrument

Once the instrument is finalized, we will conduct pilot testing to validate the instrument. Triangular data will be collected from the same pilot subjects through interview.

REFERENCES

Allan, J. (Editor). (2003). Challenges in information retrieval and language modeling: report of a Workshop held at the Center for Intelligent Information Retrieval, University of Massachusetts Amherst, September 2002. SIGIR Forum, 37(1), 31-47.

Norman, D. A. (1983). Some Observations on Mental Models. In D. R. Gentner, & A. L. Stevens (eds.) Mental Models (pp. 7-14). Hillsdale, NJ: Erlbaum.

Wang, P., Hawk, W. B., & Tenopir, C. (2000). Users' interaction with World Wide Web resources: an exploratory study using a holistic approach. Information Processing and Management, 36, 229-251.