# Designing Websites for Learning

## 1 Background

- Primarily a researcher; also webmaster for http://www.AmerLandscape.com
- Position: Research Associate, Institute of Cognitive Science, University of Colorado, Principal Investigator on NSF/CISE grant
- Ph.D. Cognitive Psychology, University of Colorado. Dissertation research on learning and transfer of problem solving skills in math, science, and spatial domains -- learning procedural knowledge, modeled as *if-then* production rules following the ACT-R cognitive architecture (Anderson & Schunn, 2002).
- M.A. Cultural Anthropology, University of Chicago. Research on culture acquisition, i.e., learning cultural meanings, cultural norms/values, and cultural models (e.g., D'Andrade & Strauss, 1992) -- learning that occurs primarily outside of formal schooling settings.
- HCI research (1999-present) to improve aviation training by applying guidelines for designing cognitive/intelligent tutors (Anderson, Corbett, Koedinger, & Pelletier, 1995) and cognitive task analysis models (GOMS). Specific issue: how to cost-effectively train commercial pilots to program the flight management computer for advanced automation aircraft (Blackmon & Polson, 2002, 2003).
- Current HCI research (2000-present) developed the Cognitive Walkthrough for the Web (CWW) to identify and repair website usability problems (Blackmon et al., 2002, 2003). CWW has roots in a theory of learning by exploration and also in Latent Semantic Analysis (LSA), a machine-based theory of semantic learning (Landauer, 1998, Landauer & Dumais, 1997; Kintsch, 1998). Since we are engaged in automating the Cognitive Walkthrough for the Web (AutoCWW), we looked to the future when naming our web server (http://AutoCWW.colorado.edu).

## 2 Designing for learning: Websites for learning metro transit system

It is difficult to learn an unfamiliar, complex transit system in real time, because mistakes can have very unpleasant consequences – e.g., getting lost in a big city or running out of tickets and/or money to get to the desired destination. Designing a website for learning is one approach to helping users negotiate the Copenhagen metro area transit system. A well designed website could make it easy for users to learn how the transit system works prior to actually setting foot on a train/bus.

### *2.1 Designing for learning by doing*

Skills are learned by doing (Anderson et al., 1995; Anderson & Schunn, 2000), so the design should allow website visitors to learn the system by practicing how to get from one place to another on the metro system, systematically exposing users to problems that cover all the necessary skill components.

People practicing a skill learn best if they engage in self-explanations, applying new inferences to repair mental models, e.g., models of how the Copenhagen transit system works (cf. Chi, 2000; Chi et al., 1994). Graesser et al. (1999) have successfully used LSA to create an AutoTutor that simulates human tutoring and the Graesser team is now developing an authoring tool for the AutoTutor. Thus, it may soon be feasible to create a web-based AutoTutor to help users learn to navigate the Copenhagen transit system.

### *2.2 Designing for learning by exploration -- by following information scent*

Web designers must carefully select heading/link labels to make it easy for users to follow information scent to accomplish their goals (Blackmon et al, 2002, 2003). According to AutoCWW, web users first focus attention on the subregion(s) of the web page that is/are semantically most similar to the user's goal and then click the subregion link that is most similar to the user's goal. To estimate semantic similarity for college-educated users of English-language websites, we rely on the LSA first-year-college semantic space.

In theory, AutoCWW can accurately predict web navigation behaviors for diverse users in any language and any culture. Semantic spaces can be built to represent speakers of any given language (e.g., English, Japanese, French, and Italian) at various levels of general reading knowledge (e.g., 3rd-, 6th-, 9th-, and 12th-grade and-year-college levels of American English and parallel levels in any other language). By expanding its repertoire of semantic spaces AutoCWW can make objective, accurate predictions for diverse user groups, potentially including native speakers of any world language at any level of general reading knowledge combined with any level of domain-specific expertise.

## 2.3 Designing for learning: Universally usable websites

An even better approach to designing for learning is developing design tools that enable web developers to create universally usable websites. These are websites that anyone can use and learn from on repeated visits, regardless of general reading knowledge, domain-specific background knowledge, or culture. On repeated visits to such a website, users have the option of starting at any level and then gradually climbing the ladder to more and more challenging web content articles, producing measurable learning gains within the content area of the website. Universally usable websites accomplish the twin universal usability goals of (1) accommodating user diversity in knowledge, literacy, and culture, and (2) "bridging the gap between what users know and what they need to know" (www.UniversalUsability.org/definition/introduction.html). In addition to well-designed heading/link labels discussed in section 2.2, universally usable websites require two special design elements: (a) content pages at multiple levels of difficulty for each specific topic, and (b) salient design elements that alert users to the option of navigating to easier or harder content pages on the same topic. These two design elements are discussed in subsections 2.3.1 and 2.3.2.

### 2.3.1 Content at multiple levels for same topic

To achieve universal usability without reducing content to the lowest common denominator, content pages can be offered at multiple levels of difficulty, giving users the option of selecting the level most appropriate to them. A concrete example is http://www.windows.ucar.edu, a website for earth and space science that offers all its content articles on three levels, called Beginner (background knowledge typical of grades 3-5), Intermediate (grades 6-8), and Advanced (grades 9-12 and adult users). The web developers accomplished this by hiring K-12 teachers as “translators” to judge the grade-appropriateness of the content.

Unfortunately, even “translators” can make mistakes in judging appropriateness of the content and using technical terms (e.g., “magnetosphere” or “mesosphere”) that have zero or very low frequencies in an LSA semantic space. Once a person has acquired an advanced level of general reading knowledge and/or domain-specific expertise it is virtually impossible to think without the acquired knowledge, even when intentionally translating the material into terms that are familiar to a group of people the translator works with daily. Therefore, unaided web designers, content writers, and even translators have great difficulty predicting the comprehension and website information search behavior of individuals whose level of general reading knowledge and/or domain-specific background knowledge differ significantly from their own.

In contrast, AutoCWW knows only what is in its LSA semantic space, a semantic space built from a large corpus of documents representative of the documents familiar to a particular group of users. By selecting a semantic space in AutoCWW that closely matches the knowledge of the target user group, the functionality of AutoCWW will enable a content writer or web designer to efficiently and effectively create web content and web navigation systems that are highly usable for diverse user groups. We are creating new AutoCWW tools that flag words with zero- or low-frequency in a target semantic space, flag passages with a high density of low-frequency words, and help content writers find suitable substitutes for zero- and low-frequency words.

Since people are learning new vocabulary all the time, the best solution is not always avoiding using all zero- and low-frequency words, but instead designing websites to facilitate learning new vocabulary, notably new domain-specific technical terms that will be required for comprehending more advanced articles on the same or related topics. In simulations of human semantic learning, LSA learns new vocabulary at a rate of ten words per day, the same rate that middle school children learn new vocabulary. Ten words per day far exceeds the number of words acquired as a result of deliberate study of new words. People learn new words whenever they use semantically similar terms, and this is particularly obvious in the case of synonyms. Synonyms (e.g., "physician" and "doctor") virtually never occur together in the same passage yet have high LSA similarity due to appearing so often with the same company (e.g., nurse, illness, hospital, medicine, and prescription).

Thus, to facilitate learning low-frequency technical terms that are essential to gaining competence in a specific content domain, content writers can by tie unfamiliar new terms to semantically similar words that are already familiar to the user group. For example, the link label *magnetosphere* has a frequency of zero in the 3$^{rd}$-grade LSA semantic space and a frequency of only one in the semantic spaces for 6$^{th}$-, 9$^{th}$-, and 12$^{th}$-grade general reading knowledge. To facilitate learning the term *magnetosphere* the tool could present the closely related terms *magnet* (frequency of 42 in 3$^{rd}$-grade semantic space), *compass* (frequency of 62), (frequency of 10), and/or *electromagnet* (frequency of 5).

### 2.3.2 Designs that guide users to optimal level for learning

There are three ways to guide users to content at the optimal level for learning: (a) sort users on the home page, (b) allow fluid self-selection to moving up or down the learning ladder, or (c) use LSA to dynamically match learners to articles at an optimal level of difficulty.

Kidshealth (http://www.kidshealth.com) is an example of a universally usable website that sorts users on the home page in order to offer medical/health information at three levels: kids, teens, and adults. Instead of offering each and every topic on all three levels, Kidshealth offers a different array of articles for each of the three audiences, assuming that teens, parents, and kids have divergent interest patterns. Requiring users to choose a subsite when entering the site causes a design tradeoff. Learners may know a lot about a disease/condition they have personally experienced but little or nothing about most other diseases, their causes, and their treatment. To navigate to more or less advanced content pages on any given topic, the user must return to the beginning, enter an alternate subsite, and navigate to the corresponding article in that subsite.

In contrast, Windows to the Universe (www.windows.ucar.edu) allows fluid movement from one level to any another level on virtually every web page in the website. The www.windows.ucar.edu site allows a person to read advanced content material on topics where the learner has a lot of background knowledge but drop back to easy material on topics where the person has little or no background knowledge. The design conventions for navigation bars, columns, or tab menus for complex websites now highlight the user's basic position within the website. Analogously, at top of each page the Windows to the Universe design puts a navigation bar with three buttons: Beginner, Intermediate, and Advanced, showing a yellow button for the current level and green buttons for the other two levels. Clicking a green button takes the user to a different level. A similar design device could highlight the user's position on the "learning ladder." The user could then click a higher rung to advance to more difficult material or a lower rung to drop back to something easier to understand. Empirical evidence is required to know which of these designs works best.

LSA could be used to dynamically match users to instructional/informational content that produces optimal learning gains, content that is neither too easy nor too hard but "just right" (Wolfe et al., 1998; Rehder et al., 1998). This design, however, would require asking users to write a brief summary of their current knowledge of the topic, something users would not generally be willing to do.

## 3 Supporting web designers designing for learning

Ivory and Chevalier (in press) have made progress in delineating how web developers do their work, and they have also shown that web developers that use automated website usability evaluation tools can produce better websites (Chevalier & Ivory, 2002). Any tool to support designing for learning will ideally integrate seamlessly into the normal workflow of web content writers and designers of web navigation system. We are, accordingly, designing AutoCWW as a plug-in to web authoring tools.

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