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Constructivism: Teaching for Under of the Internet

Anyone who has ever tried to find information on the Internet can attest to the difficulty of the task. What some see as the Internet's strength—anyone can put anything up—others see as its weakness. Many scoff at this information system as having no overall organization or consistency, and is so difficult to use. Even those who want only to "surf the 'Net" soon find out that servers and links disappear or change overnight, as do Web pages and the information they provide. And because the Internet is so popular, users soon realize they need to know who's awake in the world to be able to reach and retrieve information from any given server.

The problems inherent in any information system—disorientation, navigation inefficiency, and cognitive overload—are multiplied on the Internet. Novice users of databases or online catalogs are confused about how to search and what they find [6]. The Internet is even more disorienting because it is difficult to tell what is being searched or browsed—a single Web page, a series of pages, or a database of links. Hypertext links make it easy to navigate on the Web, but the efficiency of being able to do so leaves much to be desired, as noted by the proliferation of bookmark file editors designed to the make the task more manageable. As for cognitive overload, the amount of information which one has to wade through on the

Internet vastly exceeds the amount of information required for a given need. And it's hardly comforting to note that the only thing worse than trying to find information on the Internet is teaching others how to do it.

Part of the difficulty of teaching others to use the Internet is deciding what and how to teach them. Obviously, the Internet is a vast and complicated information system of information systems. To paraphrase Marshall McLuhan, "the message is the medium." Indeed, it is often difficult to separate system or navigational information from the real answer to a question. In fact, there are several overlapping knowledge domains in which users must have some conceptual knowledge to be able to use the Internet successfully to find information. Users must possess information retrieval skills, knowledge of how the system functions, knowledge of the subject in which they are seeking information, and problem-solving skills. Mastery in any of these areas takes time, and achieving expertise in all four areas seems like an overwhelming goal for both student and teacher. Classes and workshops on using the Internet are becoming as ubiquitous as URLs on television commercials, but teachers, instructors, and trainers are constantly asked to do more about the Internet. Users clamor for hands-on practice and one-on-one instruction, but the question always looms: "Are they really learning anything?"

This is where constructivism enters the picture. This perspective asserts that learners construct knowledge by making sense of experiences in terms of what is already known. That is, learners transfer knowledge through experiences via mental models which are used to assimilate new information into knowledge and expanded mental models [10]. After all, the goal of teaching is to have students learn, not simply learn to use the Internet. Constructivism's emphasis on knowledge construction and problem solving in domains of conceptual complexity and case-to-case irregularity applies directly to teaching in a hands-on medium like the Internet. Constructivists argue this educational approach lends itself more readily to such ill-structured domains where multiple organizational principles and irregularities in interactions exist. It is further argued that a hypertext environment could be ideally suited to reinforcing experiential learning [8]. Additionally, some researchers link constructivism with a novice-to-expert model of learning where step-like progressions via experiences are accelerated by connecting to the conceptual understanding, or mental models, of experts [2].

To understand constructivism it is necessary to look beneath the surface at the cognitive principles underlying learning, particularly the role of mental models. Cognitivists seek to explain what goes on during learning, and constructivists seek to apply it to the classroom. Both constructivism and cognitive theory assert that learners use internal, mental models to help them interpret and incorporate experiences, and then construct knowledge. Mental models basically use a conceptual understanding of a system or how things work to interact with, explain, and make predictions regarding new information. It is understood that mental models are not always accurate or complete, but they help give organization to the construction of knowledge. A mental model of a typewriter, for instance, has been used in the past by beginning computer users. With a conceptual understanding of typing they could get past the confusion of a computer as an abstract electronic tool and relate text editing to manual typing. Without some kind of organizing framework, new knowledge is likely to be handled as mere facts which have to be memorized, or bookmarks

standing

Constructivism emphasizes a creative approach to learning—a process that's particularly useful when applied to the sometimes intimidating world of the Internet.

which are referred to only when needed [9].

From a cognitive perspective, learning focuses on the mental model. Some cognitivists use the term "target" to describe the aim of learning, which is directed toward the learner. The interaction between a target system, a conceptualization of that target, and the user's application of a mental model to the target is ultimately intended to connect to a mental model [5]. A cognitive model describes this four-part system which has knowledge construction as its goal (See Figure 1). Tracing backward through the model focuses on the learner's perspective.

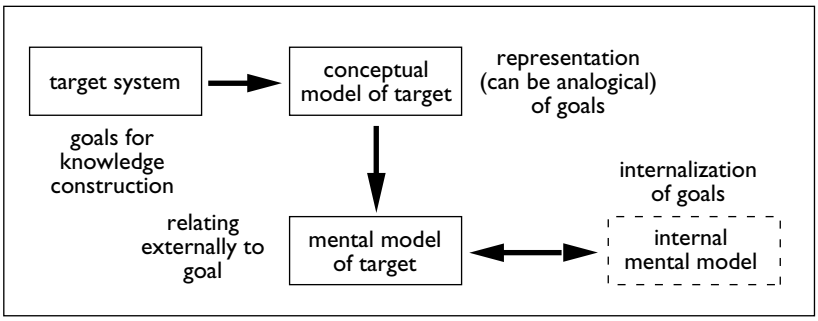

Figure 1. Cognitive model of knowledge construction

The mental model a learner will use in a given environment is considered first. Cognitivists assert that mental models are complex interactions of knowledge used to interpret the world, which are understood by users themselves through conceptualizations of those mental models. For instance, a mental model of a computer actually involves numerous intricate understandings of things like linguistic and semantic representations of symbols expressed as thoughts and words, but might be conceptualized by a user as a typewriter with memory. The first step in teaching is to assess these models through familiarity with the users' background or by surveying users. The ultimate aim of the teacher should be to aid the learner in altering, adjusting, or adding to their mental models. In order to start, the teacher must have some idea of what these models are.

A model of the target system, roughly what the teacher expects as outcomes, must connect to a mental model in order to be internalized. In theory, a learner will apply some mental model to the target in order to interpret it. But again, it should be the goal of the teacher to seek a target which matches up with a mental model, thus facilitating learning. For example, take a target of teaching users the importance of executing system commands to achieve a result on the computer. If a teacher realizes a user's mental model of computing is conceptualized as using a typewriter, it might facilitate learning to focus on keystroke commands before introducing pointing-and-clicking with a mouse. The users' ability to apply a previously held mental model to the target will enhance the incorporation and construction of new knowledge, in this case the importance of the commands themselves, not just how are they are executed.

The conceptual model of the target is the teacher's representation of the knowledge to be transferred. In traditional training (which is not learner-centered), this is usually the point where a series of steps needed to accomplish a task are detailed. The learner is expected to memorize the steps until they become second nature. But cognitivists and constructivists recognize this is a place where novices can be exposed to the kind of concepts which an expert gains through years of experience. For example, a conceptual model of a target would emphasize when and why to use system commands, not just how. In developing a conceptual model a teacher should take into account the kinds of things an expert considers, such as what problems and errors are likely to be encountered in a given situation. This conceptual model gives context and meaning to the target which further allows facilitation of knowledge through connection with mental models. Often this conceptualization can be represented by an analogy. Analogical representations are very powerful: They can give the learner a visualization that is easy to relate to, and they force the learner to compare and contrast to understand the analogy.

The target system itself is what must be learned; the primary goal of the teaching. To determine the knowledge to be learned, the teacher must keep in mind the system as a whole. And to make it learner-centered, the teacher must start from the beginning with the user in mind. What are the most important concepts? How can they feed into a broader conceptualization? How will they attach to the user's mental models? The teacher must not only focus on what is to be taught, but how it will be learned. In doing so, priority must be given to concepts that will help the learner adapt or reshape mental models. Specific objectives, such as every variation on how to delete a word or character in a text editor, often can be easily resolved once users understand the context and concepts behind the procedure.

The aim of constructivism is to capitalize on what cognitive learning theory reveals about the use of mental models. Constructivists assert that concepts

can be strengthened through interaction with the environment, especially when learners are faced with conflict or variations that reinforce their mental models. They emphasize that when experiences are carefully facilitated which support the conceptual model of the target, learners are able to adapt and reshape internal mental models and construct knowledge for themselves. In addition, it is important that experiences have meaning for the learner, not merely a coherent context. Experiences, especially those artificially designed for the classroom, must aim to match consistently and comfortably with the learner's mental models [7]. For example, someone moving from the typewriter to the computer will no doubt have a difficult time connecting to the concepts behind using system commands when exercises for reinforcement require using a mouse, if that is unfamiliar to the user. The constructivist model incorporates relevant experiences into the system (Figure 2).

A model for teaching information retrieval starts by looking at the mental models of students. Studies have shown that while students possess many of the basic skills needed for information retrieval— abilities to define a topic, formulate a search, and collect information—they usually do not possess a mental model of information retrieval as a process. Often information retrieval is seen as merely a means to an end, such as finding a book, a journal article citation, or a phone number [3]. So-called bibliographic instruction, as taught by librarians, has progressed far beyond using the library to teaching information literacy to develop models for interacting with and controlling information systems as part of a larger research process. Librarians are currently leaders as teachers and practitioners of information retrieval, and have developed a variety of successful approaches based on their expertise [4]. However, given that learners tend to have disparate or incomplete mental models of information retrieval, teachers have to start by connecting to those models already in place, such as an understanding of the organization of information in a phonebook.

The ultimate goal of the target system is to influence the construction of knowledge by demonstrating the connections between basic skills that relate to smaller mental models to build a more complete mental model of information retrieval as a process. No small task indeed, considering the proliferation of and access to so many different information systems through the Internet. Cognitivists relate the success of using analogy as a part of the target system to convey conceptual knowledge and connect to mental models. The idea is the use of analogies (metaphors, comparisons, among others) stimulates learners to think about learning by working out the similarities, or differences, that analogies describe. When analogies help learners predict or solve problems, they enrich the knowledge base upon which learners draw, and ultimately shape and strengthen mental models [11]. For instance, the analogy that a database is like a phonebook, albeit limited, allows learners to apply knowledge and skills about using a phonebook to using a database, and gives them a foundation for extending both the analogy and their mental model to understand a database as more complex, in both its structure and use, than a phonebook. In turn, the mental model of information retrieval as process can be shaped or strengthened.

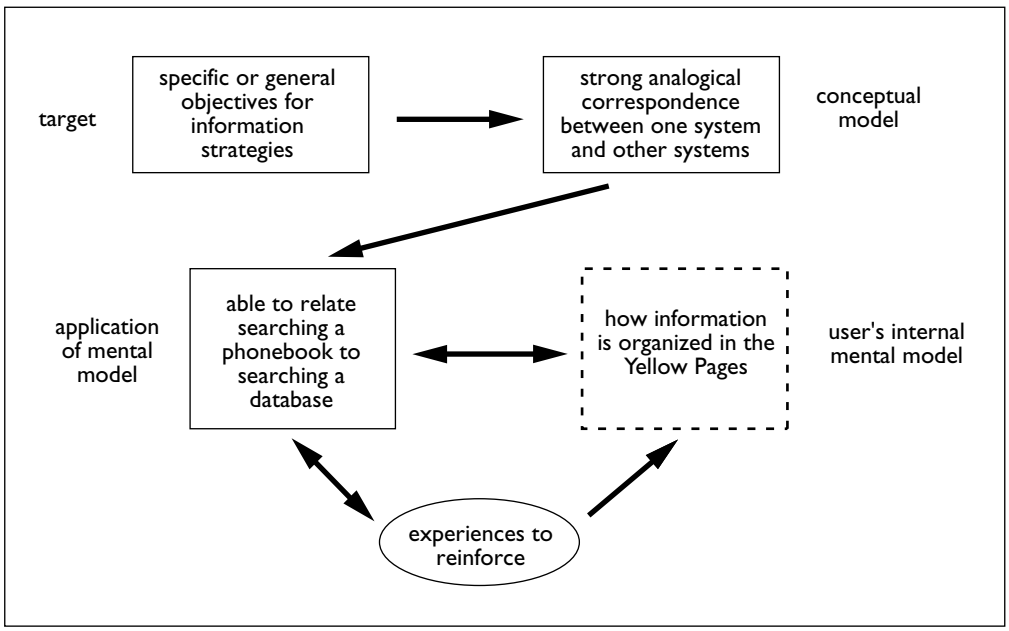

Figure 2. Knowledge construction of information strategies

Developing an analogy as part of the target system can be difficult. It should relate in some way to mental models which the learner possesses, but construc-

tivists warn it should not be too complex or oversimplified. The phonebook example possesses features which make an analogy work on several levels. As a prevalent information resource it is familiar to most everyone. It can be described simply as an alphabetical list of names, or more complexly, as a list of products and services arranged by a controlled vocabulary. As a generic representation of an information system it can be described in terms of its source, structure, and searchability—elements helpful, if not critical, to understanding information retrieval. In fact, the "3 Ss" can form a template used to understand most information systems: Who compiled the information and where did they get it (source)? How is the information treated and what does it consist of (structure)? How can the information be retrieved and manipulated (searchability)?

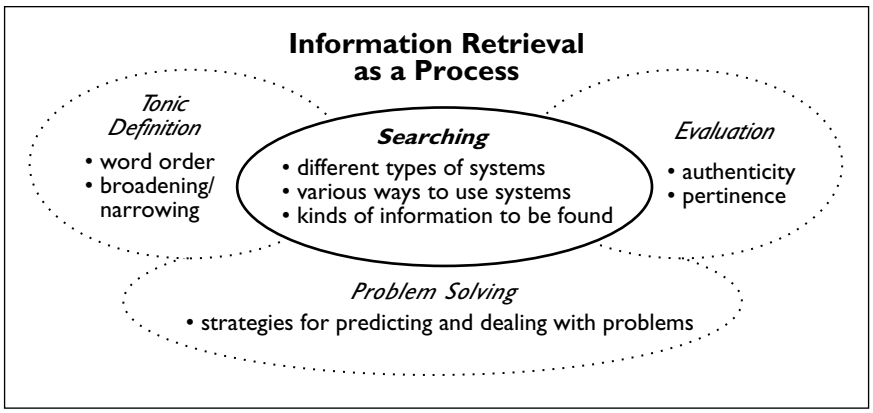

Figure 3. Concepts to consider in the overall information retrieval process

In reviewing the specific or general objectives that contribute to the overall target system, a teacher or instructor should remember that learners will more likely understand concepts, but simply memorize recipes or steps. Since the goal is strengthening mental models, more emphasis should be placed on building concepts than focusing on discrete tasks. This is not to say that individual steps or tasks should be ignored, but rather that an attempt should be made to determine if there is an overarching concept under which the steps fit, and whether the concept should be taught rather than the steps. A technique for doing this is to enumerate the various steps or tasks involved in objectives and then determine if there are categories or concepts for which the steps are examples. Specific examples can be brought out in exercises or hands-on practice which facilitate experiential learning.

For example, expert searchers understand the problems syntax and semantics bring to information retrieval. Very simply put, syntax refers to word order, whereas semantics applies to the meaning or choice of words. The concept of Boolean logic (AND, OR, NOT) is relatively simple, although applying Boolean logic to searching is not always so straightforward. The concept that AND narrows a search and OR broadens it, and are usually applied to dissimilar and similar terms respectively, is not intuitive. And the application of Boolean logic across a wide variety of databases can yield a wide variety of results. Likewise, choosing words to define a topic may seem a simple task to a user, but can become a complicated task when trying to match words in a search against either the uncontrolled vocabulary of the text of a Web page or the specific controlled vocabulary of well structured database. For instance, a search for the term "rock" on the Internet will turn up anything from music to geology to cities to people; whereas a controlled vocabulary may force the use of more precise terms, such as "granite" or "conglomerate." Rather than elaborate on all of the possible combinations that users will face in searching, the concept of word order and choice can convey the importance of search formulation as part of the process of information retrieval. But individual instances or examples of the problems with word order or choice could be built into practice sessions.

As noted, constructivists place a great deal of importance on experience in knowledge construction. Experiences do more than simply reinforce mental models through repetitive application of skills. More importantly, experiences expose the learner to variety—similarity, dissimilarity and problems—that forces learners to test mental models and adjust or change them accordingly. But just as the aim of the target system is to connect to particular mental models, so too should experiences be facilitated with particular mental models in mind. The Internet certainly offers opportunities to encounter a variety of experiences, but simply turning learners loose to surf the 'Net hardly enforces concepts or aims at a mental model of information retrieval as a process. In Purdue University's Information Strategies course, experiences are facilitated through exercises comparing searches with a variety of databases on the Internet. Concepts are introduced using a control as a benchmark (a CD-ROM index or online catalog) and simi-

larities or differences between other systems are brought out through the exercises. Concepts related to searching, and the experiences gained from performing searches, are an integral part of the overall information retrieval process (see Figure 3).

While it was noted earlier that the Internet lacks organization and consistency, this should in no way detract from the abundance and usefulness of information which can be found there. However, a conceptual understanding of information retrieval is critical to finding what is needed. And because of the complex nature of how information is stored and retrieved in a digital networked environment, it is often necessary to have a conceptual understanding of the Internet itself.

One analogy that seeks to help beginners grasp the basic concepts behind a client-server architecture is the PLACES (Purdue Libraries Application for showing Clients Evoking Servers) Game—a simulating, role-playing exercise [1]. Basically, PLACES simulates the interactions between a client and servers to demonstrate how information is retrieved on the Internet. The goal is to give learners an understanding of the technology that underlies information retrieval and contributes to the ease (and difficulty) of retrieving information. Participants are given a folder of Web pages and act as a server waiting for requests. A client follows the URL addresses behind a hyperlink to retrieve Web pages from the servers. The simulation is designed to help participants understand that how information is transmitted across the Internet often influences the success of retrieval. Concepts relating to how servers maintain information, when they are available, and what the client does with information retrieved, as well as techniques to deal with certain situations, are discussed as part of the simulation. Though not specifically related to information retrieval, a conceptual understanding of the Internet as a system is often necessary to help build confidence and competence in using the Internet.

Likewise, subject knowledge or problem-solving skills may not be critical to information retrieval, especially in its simpler forms, but they are ultimately linked to finding relevant and reliable information. Simply put, someone who possesses subject knowledge can verify the validity and usefulness of information. Those without subject knowledge need to be shown how to evaluate information found both objectively (its authenticity or timelines), and subjectively (whether it fits the user's need). Problem-solving skills are needed whenever difficulties arise and alternative solutions must be explored. Experts draw upon a wealth of experience to develop options. Novices must be shown ways to approach problems. For instance, with a conceptual understanding of client-server interactions, users can interpret the infamous 404 Not Found error message as an out-of-order phone number, or a busy line to be tried again later.

While the goal of constructivism is to recognize and help facilitate the learner's ability to construct knowledge, when applied to teaching information retrieval on the Internet it also provides the teacher with a structure for teaching. By focusing on concepts and connecting them to mental models, instructors and teachers can gain both confidence and control over the amount of material they cover in the small blocks of time usually allotted to teaching and training. Integrated with experiences that learners use to alter and strengthen mental models, a constructivist approach to teaching information retrieval also gives users a needed structure to get the most out of the Internet.

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