

# A Conceptual Model For Learning Internet Searching On The Internet

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## Abstract

*Although the Internet offers many exciting opportunities for communication and exploration, learning how to use it effectively is a daunting task for novices. The volume of information and its lack of organization present a real danger of cognitive overload. Searching for information is even more frustrating. How can we help novices to search the Internet effectively? One solution is to develop a courseware, using conceptual models based on constructivism, to teach them how to search. This paper describes the process we used to design and develop the conceptual models to teach Internet searching. We begin with a brief review of constructivist learning, mental models and conceptual models. This is followed by the process we used to develop the necessary conceptual models, using the Courseware Engineering Methodology (CEM). Next an evaluation of the conceptual models is given. The paper concludes with suggestions for future research.*

## 1. Introduction

The Internet and the World Wide Web (WWW) are perhaps the world's largest information repository today. To be able to use the Internet effectively is not a trivial task. Anyone who has ever tried to find information on the Internet can attest to the difficulty of the task. The problems inherent in any information system – disorientation, navigation, inefficiency and cognitive overload – are multiplied on the Internet. Novice users in particular find it frustrating when it comes to how to search the Internet and what they find [7]. It is also more disorienting for novices because it is difficult for them to tell what is being searched or browsed; a single web page, a series of pages, or a database of links. Hypertext links may be able to ease navigation on the Internet, but they bring with them the problem of disorientation.

To use the Internet effectively novices need to be able to locate and retrieve the relevant information. Usually the amount of information one has to wade through often exceeds the amount of information required for a given need. The problem is further

compounded when we have to teach others to search for information on the Internet. Part of the difficulty of teaching others to use the Internet is deciding what to teach and how best to teach them. There are several overlapping knowledge domains in which users must have some conceptual knowledge to be able to successfully use the Internet to search for 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 [1]. Mastery in any of these takes time. Expertise in all four areas seems like an overwhelming goal for users in general and novices in particular. These problems are not helped by the fact that browsing the Internet can seem different from using the 'normal' office applications on the PC. Even people who proficient in basic computing skills and have lengthy experience of using traditional software can be confronted by many problems when using the Internet. It appears that the perception of the Internet is that it is very different hinders the transfer of appropriate knowledge from the off-line to the on-line domain. What is needed is conceptual knowledge of the Internet and the tasks that can be performed on it. How, then, can we help novices to search for relevant information effectively on the Internet? One solution is to develop a constructivist learning environment that would help novices to learn about Internet searching using conceptual models.

This paper describes the development of the conceptual models using Applied Cognitive Task Analysis (ACTA) method. The conceptual models are then integrated into a web-based courseware for novices to use. The paper begins with an overview of the use of mental and conceptual models in constructivist learning. It is then followed by description of the process used to develop the conceptual models. Evaluation of the conceptual models is carried by novices using the web-based courseware. The paper concludes with further work to be carried out.

## 2. Constructivist Learning

Constructivist learning holds that learners learn new knowledge by refining to things already known or

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experienced. Constructivist teaching seeks to help learners to construct advanced knowledge that will support problem-solving skills and expert task performance. It is ideal for teaching a complex and ill-structured domain such as the Internet. According to constructivists, users construct knowledge about a new system by transferring and expanding existing knowledge through mental models [1]. Mental models are the user's internal representations of their interaction with the system [8]. These models are used to provide the person with the power to understand and predict system behavior, although they need not be technically accurate to do so. A mental model of a typewriter has been used to teach word processing to users. With a conceptual understanding of typing, users could get past the confusion of an abstract electronic tool and relate editing to manual typing. When learners are provided with conceptual models and situated experiences that reinforce those models, their mental models will be extended and developed.

A mental model is developed as a user interacts with a system. Users create new mental models to describe the target system by means of structural mapping; that is, users map the structural relations of an existing model onto the new [2]. The conceptual model of the target system is created by the teacher and encompasses the knowledge that is to be transferred to the learners. The conceptual model is usually represented by an analogy or metaphor. Analogy is extremely powerful because it presents a description of a system by reference to existing knowledge held by the user. Furthermore, usage of the system forces the user to compare the similarities and dissimilarities between it and the analogy presented. We believe that the development of good conceptual models can help to bridge the gap that exists between novice and expert Internet users. Thus, the goal of the teacher or designer is to seek a conceptual model of the target system that matches up with the user mental model to facilitate learning.

There is evidence provided by researchers that conceptual models are useful in the learning of complex tasks. Mayer [4] concluded that providing concrete conceptual models for learners improves conceptual retention, reduces verbatim recall and improves problem-solving transfer. Good conceptual models make intuitive sense to the learners and use vocabulary and concepts that are appropriate for the learners. The reason for intentionally illustrating the conceptual components enhance learners' mental models of the content being structured. Conceptual models can be effectively presented before instruction or during instruction. Another reason for providing learners with the conceptual models of the problem solving domain being studied is because they explicitly represent the structural knowledge required to support problem solving [3].

### 3. Development of conceptual models

The following sections describe how we developed the conceptual models for our web-based courseware. A novice user population was surveyed to discover deficiencies in their mental models of computing and Internet technologies and tasks. Expert users were interviewed and a cognitive task analysis performed to identify areas for the development of conceptual models relating to Internet search.

The development of the conceptual models consisted of three steps:

1. Capturing novices conceptual models
2. Development of conceptual models
3. Representation of the conceptual models.

#### 3.1. Capturing novices conceptual models

The first step in our design is to assess the mental models of the novices who would be using the system. As it is not possible to fully obtain an accurate mental model for all users, we would only consider where mental models are incomplete or erroneous, by researching the classes of problems that novices have when using the Internet technologies. Our first task is to assess these mental models through familiarity with the users' backgrounds.

In order for a teacher's conceptual model to be effective in facilitating learning, Norman [6] proposed that the conceptual model should meet three basic criteria: learnability, functionality and usability. Learnability means that the conceptual model should be easy to learn. Functionality means that the model corresponds to important aspects of the target system as it is designed. Usability implies that the model should be easy to use, given the limitations of the human information processing system.

The main aim of the learning environment we want to develop through constructivism is to provide learners with carefully designed experiences of the target system so that they can adjust their mental models and to construct knowledge [1]. To achieve this we conducted surveys both with novices and with expert users of Internet technology.

We begin with the collection of data from novices in order to find out as much as possible about their existing mental models with respect to their experience of the Internet search. We conducted surveys with novices from various backgrounds, which initially involved the distribution of a questionnaire to our eighty users. Administering the questionnaire provided an opportunity to discover common problems encountered by novices and their perception of the Internet. This allowed us to identify the most appropriate questions to ask during the follow-up interviews. Sixty-three questionnaires were returned. Some forty-four of the respondents were school or college students. The follow-up interviews were conducted at a Staffordshire High School. The

interview questions were more focused on gathering information about subject's conceptual knowledge as this would help us identify current levels of understanding and deficiencies in the mental models of the users. This information is vital because it helps us design useful conceptual models of the target system that will connect with the users' mental models.

Some of the questions asked were concerned with the problems that users encountered when using computers and the Internet. In particular, some questions concerned problems of navigation (both on-line and off-line), such as getting lost through folders (off-line) and getting lost on the Internet. We also sought to discover how many users used keyboard shortcuts or the right mouse button to access menus. These are important indicators of lack of computing ability and mental model development. Only three people mentioned shortcuts. It would appear that novice users did not realize that it is possible to use shortcuts when browsing the Internet. This tied in with information gained in the follow-up interviews that users did not perceive using the Internet to be similar to using the computer in any other situation. It would appear that mental models of computer usage were not being employed and developed when browsing the Internet. Another point of discussion was the task of moving data (either text or image) from a web page to another document. Only two people interviewed mentions copy and paste as a method of doing this. The main problem we found was that users lack conceptual knowledge about cutting and pasting. Not surprisingly, searching on the Internet caused a large number of problems for users. The main problem was due to the users having little or no concept of searching as a process and the effect of syntax, semantics and Boolean logic on the results returned. Our follow-up interviews confirmed that there appeared to be a gap in the users' conceptual knowledge of the search mechanism. Many did not see the link between the Internet search activity and other search methods used. In this respect it was interesting that no-one suggested the file finder application on the local computer was similar to Internet-based searching, which implied that the users were unable to link their mental models of off-line searching to on-line tasks. Novice users also had little or no concept of how a web page was downloaded onto their computers. Mental models are clearly under developed in this area, which was identified as an area for the development of a conceptual model. With a model of the web page downloading process, users would be able to understand issues that affect the speed of transmission of data or error situations such as the HTTP 404 'File not found' error.

Yet another area identified for the creation of a conceptual model was that of the Internet address, the Uniform Resource Locator (URL). Users have little or no idea what the constituent parts of the URL mean, and this can hamper problem solving in certain

situations. Specifically, users do not recognize the parallels between the fact that a house address is made up of a number of elements that provide different levels of information about the location (street, city, country) of the house, and that the URL also has distinct elements that identify a particular computer, the domain that computer resides in and the service that is required of it. Furthermore, the novice users are not aware that, in effect, the Internet is one big (and very dynamic) file system and that the slash separators in an address signify directories on the remote computer. Consequently, they could not apply the mental models they have of the file systems and file manipulations. This impacts upon their problem-solving abilities. For example, when users come across broken links, or cannot find a file or page they expect to find at a web site, they often do not know how to go about solving the problem. By applying knowledge of file systems and directory structures to the structure of URLs, users can strip parts of the address in the hope of being presented with a directory structure to browse.

### 3.2. Developing the Conceptual models

Next, we develop a model of the target system. The conceptual model of the target is the designers representation of the knowledge to be transferred. In designing conceptual models, designers must take into account the kind of things an expert considers, such as what problems and errors are likely to be encountered in a given situation. This conceptual model thus gives context and meaning to the target, which further allows facilitation of knowledge through connection with novices mental models. In order to develop conceptual models to help novices in their understanding of the Internet search, we have to interview experts. This is necessary because a conceptual model must provide an accurate and consistent representation of the target system.

As the activities involved in searching the Internet are complex cognitive tasks, we have chosen the Applied Cognitive Task Analysis (ACTA) method to elicit the cognitive skills or mental demands needed to perform the task proficiency from the experts. The main reason for choosing ACTA is that it is a streamlined version of analyzing complex cognitive tasks that is designed to be more useful for the design of actual systems and easier to perform than other cognitive task analysis methods. ACTA is a structured interview method for eliciting appropriate task knowledge from subject matter experts [5]. As a methodology, ACTA is particularly suited to the generation of learning objectives and the revision of existing, or creation of new, training manuals.

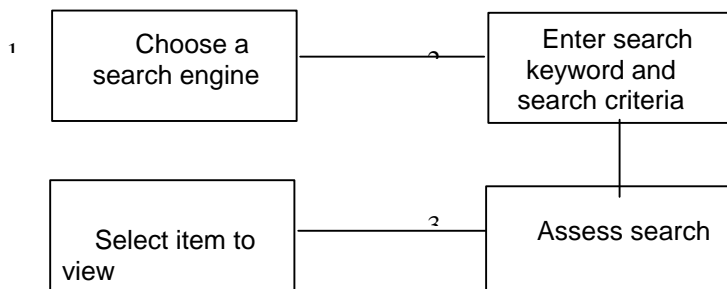
The three interview types that comprise ACTA are the task diagram, the knowledge audit and the simulation interview. The interviews aim to help

experts verbalize the cognitive strategies used in task performance.

**Step 1. The task diagram**

The task diagram is the preliminary interview and is intended to elicit a broad overview of the task or tasks. The first step of ACTA begins by asking the subject

matter experts to break down a particular task of interest into four or five steps and to highlight which of the steps requires different cognitive skills. Five SMEs were interviewed, the information collected was documented and a task diagram constructed as illustrated in Figure 1.



Legend:  Task requiring difficult cognitive skills.

Figure 1. Task Diagram for Searching for Information on the Internet.

**Step 2. The knowledge audit**

The knowledge audit step elicits the aspects of expertise required for particular tasks or subtasks. The interview is based upon 'knowledge categories' such as diagnosing, predicting, perceptual skills, improvising and recognition of anomalies [5]. A series of questions or probes that address each of the knowledge categories are used to obtain information about whether the particular skill is present in a task. In addition, strategies for its use and specific examples of its use are uncovered. The example is probed for the cues and strategies used in determining and dealing with the situation and potential errors a novice might make in

the same position. The probes chosen for the knowledge audit in our example encompassed knowledge categories including past and future, big picture, noticing, job smarts, opportunities/improvising, self-monitoring and anomalies. A tape recording of each knowledge audit interview was reviewed and the data organized into a knowledge audit table. The table includes examples of where a particular skill (knowledge category) was used, the cues and strategies used in dealing with the situation and why the situation might be difficult for novices. Table 1 shows an excerpt from a knowledge audit table generated by one of the interviews.

Table 1. Entry form Knowledge Audit Table

Knowledge	Cues and Strategies	Why difficult
When several searches fail on various search engines, switch to searching newsgroups or mailing lists for the desired information.	Searching newsgroups and mailing lists; their FAQ's can contain useful information – occasionally more than was required about the topic.	Novices give up too easily when their searches fail to return desired information. They tend to restrict their search to one method – failing to discover other options.
Equipment difficulties e.g. HTTP 404 error, web page does not exist.	Don't always believe the computer because this is a general error. Does not necessarily mean the file does not exist. Possible other reasons for error message such as a busy server or timed-out request. Reclick the link a couple of times. Be patient in waiting for the page to load.	Novices find error messages cryptic and difficult to understand. They tend to believe what the computer is telling them. They don't know about the many problems that can cause this error. Might not try relicking the link.

**Step 3. The simulation interview**

In the simulation interview, information about the SMEs cognitive processes within the context of an incident was gathered. This was accomplished by the presentation of a challenging scenario to the SME. The one challenging scenario was "Full text search using a search engine" The biggest challenge with any type of on-line searching is choosing the right search terms or

keywords. Because web search engine databases make no distinction between the various types of information available about a certain topic, doing a search about, say, a famous author, will probably get a hotchpotch of web sites, many of them personal home pages created by fans of the said author. The information elicited from the SME about the above challenging scenario was recorded in the simulation interview in Table 2.

Table 2. Simulation Interview Table.

Event	Actions	Assessment	Critical Cues	Potential Errors
Need to search for information	Choose a search engine. Load the search engine	Searching for information about a topic or for pages containing a particular word or words?	For a topic, use subject-based engine e.g. Yahoo. For every page use index-type engine e.g. Altavista	Novices don't know of different search engine types and effect on usefulness of results returned. Tend to stick to first search engine used.

Table 3. Excerpt from Cognitive Demands Table

Difficult cognitive element	Why difficult?	Common errors	Cues and strategies used
(1) Knowing when a search is likely to be unsuccessful.	It is natural for anyone to wait for the search engine to return results, analyze them and decide on the next course of action. There could be many reasons that cause a delay in returning results.	Novices, being inexperienced, tend to just wait for the result without paying attention to cues provided by the status line of the browser about connection status.	When a search is taking too long, look for cues provided by status bar of browser. A long unchanging "connecting to <domain name>" status could mean that the search engine is too busy or down. In this case, switch to another search engine without wasting time.
(2-5) . . . . .	. . . . .	. . . . .	. . . . .
(6) Performing full-text searches on search engines.	Search engines databases contain topics indexed or sorted by keywords. Hence, the use of the right keyword is critical to obtaining relevant results. A search using keywords like <i>apple computer</i> will return results about not only the computer manufacturer, but also whatever links relate to the fruit (apple) and all links pertaining to computer!	Novices tend to misspell or use too ambiguous a keyword. Sometimes, this can be due to novices lacking knowledge of the subject topic, hence failing to predict what may be returned for a given keyword.	Spelling mistakes and keywords that are too general and non-unique will all result can be avoided. To restrict a search about the hardware manufacturer, <i>Apple computer</i> , one can use double quotes to enclose the keywords, such as "Apple computer" together with an Boolean expression such as AND NOT to exclude any other topics that may result in ambiguous searches.

#### **Step 4. Sorting Out Key Tasks**

The final stage of the ACTA process is the construction of a cognitive demands table to sort through and analyze the data collected in the previous three stages. This step allows the less relevant bit of information to be filtered, thus, focusing the analysis only on specific goals. A partial cognitive demands table is shown in Table 3.

This ACTA analysis revealed the difficult cognitive elements in Internet tasks, the kinds of problems an expert expects when performing these tasks, strategies for solving problems and why the tasks might present problems to novice users. These types of information are important components of the conceptual models to be developed. Presenting the information to novice users in conceptual models is a fundamental aspect of constructivist learning [1]. The data collected during the ACTA analysis are used to develop the conceptual models that would be implemented in the constructivist learning environments for novices to learn about Internet searching.

### **3.3. Representation of conceptual models**

We next developed analogies to represent the conceptual models derived from the above analysis. We believe that analogical representations are very powerful. They can give the novices a visualization that is very easy to relate to and they force the novice to compare and contrast to understand the analogies. The analogy chosen should relate to existing mental models held by these users. Often the analogy alone is not enough to accurately convey the conceptual model. Learners must be encouraged to look at the similarities and dissimilarities between the analogy and the target system. This can be achieved by supplementing the analogy where necessary with appropriate technical information about the target system and with practice examples that lead the learner to compare and contrast. Analogies can be tailored to help the learner acquire problem-solving skills.

In order to understand the (unfortunately common) problems associated with loading web pages, some of the underlying mechanism of the transfer of data must be incorporated into the conceptual model. In this case, major concepts include the client/server model, the need to make a request of the server for a web page and the subsequent reply from the server (either an error message or the requested page). Possible problems when requesting a web page can include: the original request being lost, an extremely slow response from the server, a time-out of the original request, the reply from the server getting lost or timing out, etc. Therefore, the conceptual model must address the fact that problems can occur with firstly the request and then the reply.

An example of an analogy we have developed to convey this was that of ordering a pizza over the

telephone from a pizza restaurant. In this analogy, the person ordering is the client, the restaurant is the server and the pizza would represent the web page or file that was to be downloaded. Initially the person must make a request or order the pizza. To do this they need to know the telephone number of the restaurant. On ringing the number, one possible problem is that it will be engaged. This is analogous to a server not replying to the initial request for a web page and illustrates that the request for a web page has to reach the server to be satisfied, but may possibly 'fall at the first hurdle'. One reason for a request not reaching a server is that the server is extremely busy dealing with other requests. Again, the engaged line can convey this possibility.

This analogy can be particularly useful in helping users interpret error messages that they receive whilst browsing. Rather than implicitly accept that an HTTP 404 error means that the page requested does not exist, or that a server is down or inaccessible, the user can interpret it as a busy line to be tried again. Redialling the number of the restaurant or re-clicking the hyperlink a few times often cures the problem.

The pizza restaurant analogy can also help to explain other possible problems in the delivery of a web page to the client computer. If the pizza restaurant is very busy with lots of orders (requests for web pages) to deal with, it is likely that the order take longer to be fulfilled and dispatched. With the Internet, as with pizza, patience is the key. The speed of delivery is not only influenced by how busy the restaurant (server) is, but also by the amount of traffic on the roads between the restaurant and the client's house (computer). If the traffic is very busy on the roads (or the networks that constitute the Internet), it is likely that it will take longer for the delivery to arrive. Furthermore, there is always the chance that the delivery person will get lost, as can happen with the reply from the server.

We then built the conceptual models into a web courseware application using constructivist learning principles for both Internet Explorer and Netscape. Since the goal of our learning environment is to strengthen models of the novices, we placed more emphasis on building concepts than focusing on discrete tasks. This is not to say that individual steps or tasks are ignored, but rather that the steps or tasks should be learned in context. To achieve this we used appropriate situated examples for novices to work through. The exercises were also designed along constructivist principles to reinforce the conceptual models. Topics for novices include hyperlinks, URLs, HTML, the history mechanism, cut & paste, searching and web site structure and organization (including home pages).

In order to address the need for technical knowledge, the conceptual model presented for the task of following a hyperlink, for example, is described not only by an analogy, but also by concepts that underline the loading of a web page, such as client/server, request/reply protocols, etc. Procedural knowledge is

also supplied where this constitutes 'tricks of the trade' such as the use of the right mouse button as a shortcut to access context-sensible menus. An example of the

screen shot of the learning environment is shown in Figure 2.

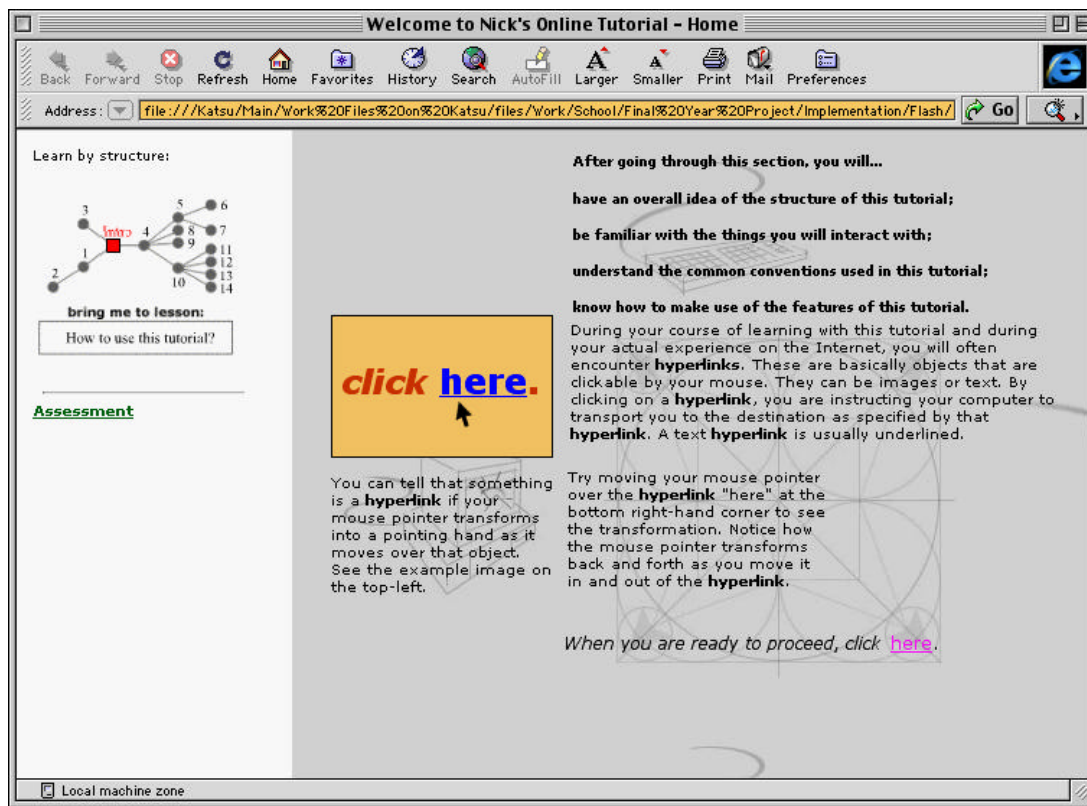


Figure 2. Sample screen shot of the courseware's main intro. page.

#### 4. Evaluation

In order to assess the effectiveness of the courseware, we need to define our criteria. Because the domain of interest, such as an Internet search, is an ill-defined problem, it is necessary to present the learner with novel problem situations to use. The aim of the exercise is not to look for a right or wrong way to answer, but more on the thought processes of the learners while deriving the solution. For the assessment, learners are presented with a novel situation for which they are asked to work through a set of problems.

We gave the courseware to a second set of novices to evaluate. These were 26 students from a class of 29 university students. (The remaining three claimed to be experts at searching on the Internet and were omitted from the evaluation group.) To evaluate the courseware module, they were each given the same searching exercise to undertake, working alone, using the courseware module.

Following the learning exercise each was given a questionnaire to answer, following the exercise. The questionnaire used multiple choice questions, as a 5

point ranking, to elicit the novices opinions on ease of navigation through the module, how easy they found the module to follow, its balance, comprehensiveness and interest, together with Yes / No questions on whether using it had boosted their understanding, their knowledge and their confidence in Internet searching. Comments about their own skill levels and about aspects not addressed by other questions were also elicited.

Only 4% of subjects had difficulty in navigating through the module, with 96% of subjects giving the top two rankings for these questions. 73% judged the module easy to follow giving the top two rankings, while 92% gave the top three rankings. From this we conclude that the subjects were not obstructed in their learning by the structure or language of the module.

The subjects found the material in the module balanced with 66% giving the top two rankings and 88% giving the top three rankings. Their interest in the subject matter was lower with 58% giving the top two rankings and 88% giving the top three rankings. Strikingly their assessment of the comprehensiveness of the module was essentially critical with only 50% giving the top two rankings, although 96% gave the top

three rankings. This latter outcome leads us to recognize that perhaps the subjects knew more of the topic than they claimed and that more detailed probing of knowledge status should be undertaken in future tests.

The questions addressing the effects of the module on the learning outcomes for the subjects found that 65% considered that it had increased their understanding, 60% that it had increased their knowledge but only 54% that it had increased their confidence in searching on the Internet. The first two outcomes are lower than we had expected, but may be due to a greater initial level of capability than we had measured. The figure for increase in confidence is more disappointing and would be difficult to explain in terms of already high confidence of subjects in their ability. Our experiences with the group do not support this. It may be that we administered the evaluation questionnaire too soon after the learning experience, before the subjects had the chance to develop their new skills through practice.

The comments elicited a problem concerned the need to scroll down the screen in order to view the whole of a lesson which exceeded the screen length. We rectified this problem following the feedback from the subjects. Further comments indicated that the 'history mechanism' element of the module was too 'wordy', with comments that an alternative approach to text was required to help comprehension and retain interest.

Generally, we can claim that the majority of the novices found the learning environment useful in helping them to understand the basic principles of searching on the Internet. Evaluation by the second novice user population confirmed that the conceptual models were useful and helped them to have a better understanding of the search process involved and how to locate necessary information.

## 5. Lessons learned

We have learned many lessons through the development of the conceptual models. Firstly, we discovered that the capture of users' mental models is not easy because the existence of mental models can only be inferred. They cannot be directly seen or measured. Secondly, the development of conceptual models that match the mental models of users is not trivial. The use of appropriate metaphors is critical to the success of good conceptual models. Thirdly, mental models differ in quality between novices and expert users. Expert models are more abstract and represent higher functioning levels of the system. Novices, on the other hand, tend to represent more concrete knowledge. Fourthly, ACTA provides us with a powerful analysis tool to elicit the task knowledge of the expert. Fifthly, the development of analogies to represent conceptual models derived from our analysis is often a trial and error process. We first have to

understand the background, experience, culture and mental models of the user. Often, analogies alone are not enough to accurately convey the conceptual models. Learners must be encouraged to look at the similarity and dissimilarity between the analogy and the target system. This has to be achieved by supplementing the analogy where necessary with appropriate technical information about the target system and practice examples that lead the learner to compare and contrast.

## 6. Conclusion

Learning how to search on the Internet effectively is a complex and ill-structured task. Successful Internet use requires problem-solving skill and technical concepts that are only acquired through experience. Teaching those concepts to novice users by connecting to their mental models facilitates the acquisition of expert-level knowledge. Reinforcing those concepts with examples situated in context will help to shape and alter users mental models.

We have demonstrated in our case study that using appropriate conceptual models that are connected to users' mental models can help users learn searching on the Internet. It is our belief that the idea of the use of carefully derived conceptual models stimulates learners to think about the similarities, or differences, which conceptual models describe. Using conceptual models that are connected to the users' mental models helps learners predict or solve problems. They enrich the knowledge base upon which learners draw, and ultimately shape and strengthen their own mental models. The example, albeit limited, of the analogy that searching a web page is like ordering a pizza, allows learners to apply knowledge and skills about ordering a pizza to using the Internet for searching, and gives them a foundation for extending both the conceptual models and their mental models to understand searching a page as more complex, in both its structure and use, than ordering a pizza. This in turn enables the mental model of searching as a process to be shaped and strengthened.

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