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ABSTRACT

The purpose of this exploratory study was to compare three experts and three novices in a Web-based problem solving context. The task was to search and evaluate Web sources for writing a research paper on a topic (inquiry based instruction, or IBI) that was unfamiliar to the users. The following research questions guided the study: (1) What type of navigational strategies do experts and novices employ to search for information on the Web?; (2) What are the novices' and experts' attitudes and feelings during the search?; and (3) What type of metacognitive strategies do experts and novices use during the Web search? Lessons learned from studying novice and expert Web users have significant instructional implications for educators and designers. Study emphasized that searching information on the Web is a complex phenomenon that requires developing a Personal Information Structure. An appendix presents a list of categories and scores for all novices and experts; and a list of sites shared among some participants and missed by other participants. (AEF)

Searching the Web: Expert-Novice Differences In a Problem Solving Context

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The Problem

The World Wide Web has increasingly become a research hot topic, and studies about searching the Web are blooming across a variety of fields such as library and information sciences (Jayne & Meer, 1997), educational psychology (Windschitl, 1998), and business (Urgo, 1997). Yet, the majority of these studies focus on the technological and commercial aspects of the Web. They critically evaluate different search engines (Poulter, 1997) or describe specialized databases (Kurkul, 1997; Shue & Hue, 1997). What are missing are more empirical in-depth descriptive studies that focus on the user's knowledge base and cognitive and affective processes while searching the Web (Hill and Hannafin, 1997; Kafai & Bates, 1997).

Our interest in the Web stems from the fact that it has the potential to be a powerful educational tool (Hackbarth,1997; Owston, 1997; Ryder & Hughes, 1997; Windschitl, 1998). However, searching for information on the Web can be problematic due to the nature and vastness of its database. Immediate access to a large quantity of information that has not been systematically evaluated might present more complex problems than conducting a search in a traditional library (Fung, 1997). Therefore, when searching the Web, users must apply their critical thinking skills, metacognitive and navigational strategies in order to successfully evaluate the reliability and validity of the sources, as well as to avoid getting lost in cyberspace (Jones, 1997; Marchionini, 1997).

The purpose of this exploratory study was to compare three experts and three novices in a Web based problem-solving context. The task was to search and evaluate Web sources so as to write a research paper on a topic (inquiry based instruction or IBI) that was unfamiliar to the users. This study differs from other studies on problem solving because the task is open-ended and it also includes problem finding (Getzel & Csikszentmihalyi, 1975) and as such, it provides an added dimension to this area of research. Focusing on how novices compare to expert Web users in searching the Web, the following research questions guided this study: 1) what type of navigational strategies do experts and novices employ to search for information on the Web? 2) what are the novices' and experts' attitudes and feelings during the search? and 3) what type of metacognitive strategies do experts and novices use

during the Web search? Lessons learned from studying novice and expert Web-users, have significant instructional implications for educators and designers.

Theoretical Framework

Due to the ill-defined problem solving on the Web and the hypertext nature of the Web environment, theories about cognitive flexibility (Spiro, Feltovich, Jacobson & Coulson, 1991) and expertise (Ericcson & Lehman, 1996) form the framework for this study. From the information science literature, this study borrows the concept of Personal Information Infrastructure, or PII (Marchionini, 1995) defined as

> "...a collection of interacting mental models for specific information systems; mental models for events, experiences and domains of knowledge; general cognitive skills (e.g. inferencing, recognizing salience) and specific cognitive skills related to organizing and accessing information (e.g., filing rules, reading); material resources such as information systems, money and time; metacognitive resources for planning and monitoring thought and action; and attitudes toward information seeking and knowledge acquisition...The level of development of a person's information infrastructure is roughly analogous to the level of his or her information literacy" (p.11-12).

In agreement with Marchionini (1995), in order to investigate information searching it is important to use the PII model, which integrates different components such as cognitive, metacognitive skills, attitudes and feelings as well as material resources. In this paper, only parts of the results in three categories (navigation, metacognition and affect) are reported. In the future, this will be complemented with other categories such as evaluation and cognitive strategies.

Expert-novice differences have been studied to determine the initial state of the learner (novice), and what is required to become an expert. From this research it is known that the course of knowledge acquisition proceeds from a declarative to a procedural, condition-action form (Glaser & Bassock, 1989). This difference is between knowing what and knowing how. Novices may acquire the same amount of information as experts without knowing the condition of its application. Experts, on the other hand, seem to acquire knowledge in relation to its function and applicability (Chi and Glaser,

1985). Novices tend to categorize problems by surface features whereas experts look for patterns and analytic strategies (Chi, Feltovich and Glaser, 1981). Experts have more in-depth prior knowledge and, through chunking, can switch faster from one strategy to another when faced with difficulty on a problem (Presley and McCormick, 1995). Ericsson, Krampe, & Tech-Romer (1993) argue that it takes 10,000 hours or 10 years in the field to become an expert. Due to the relative novelty of the Web, in this study, expertise is defined in terms of hours of Web access and not necessarily years of familiarity with the Web.

Methodology

Due to the ill-structured nature of the problem, cognitive task analysis (Shute, 1997) and verbal protocols (Ericsson & Simon, 1993) were used to gather and analyze information. The sample consisted of three novices and three experts, all graduate students at the Faculty of Education (McGill University). We assumed that these students from this Faculty would be better equipped to verbalize their knowledge. Experts were Web-based course designers and teachers. Novices shared similar computer literacy and research assistantship background. The criterion, which differentiated novices from experts, was the amount of time spent on the Web. The novices' time was on average less than 3 hours a week, whereas for experts it averaged 15 hours a week. Performance measures were the differences between how experts and novices searched the Web in order to solve the problem at hand (Table 1). The task lasted approximately 1 hour. One researcher reminded the participant to think aloud while searching the Web, the other one videotaped the sessions. This division of tasks was kept constant with all participants in order to increase the reliability of the procedure. A socio-demographic and training questionnaire was filled out before the task. After the task was completed, participants were asked about different topics related to Web searching. Their responses were triangulated with the training questionnaire and cognitive task analysis results. Member checks were done before the final data analysis. For data analysis, a coding scheme was created with 7 categories subdivided into subcategories and topics. The categories emerged from the initial open-coding analysis of the data (Strauss & Corbin, 1990). The intercoder reliability was approximately 90% (Miles & Huberman,

1994). In this paper, novices are identified as N1, N2, and N3. Experts are identified as EA, EB, and EC.

Findings by research questions To answer the research questions, experts and novice Web-users were compared in three categories: 1) navigational strategies; 2) metacognitive strategies; and 3) affect (see Table 1.)

1. Navigational strategies:

Navigational strategies included three subcategories: 2.1 moves, 2.2 direction of search, and 2.3 waiting. Overall, novices scored less than experts (110 vs.152) due to their limited system knowledge.

The subcategory Moves was subdivided into 9 topics such as 2.1.1 *backwards moves*, 2.1.3 *accessing a search engine*, 2.1.4 *clicking*, and 2.1.9 *reloading* the Web page. Overall, novices had less moves than experts (72 vs. 87). Most of these moves included actions such as backwards moves, clicking, scanning, and reading. Backward moves and clicking were the largest in this subcategory. Within the novices, N3 was the one who had the highest number of moves, almost the double of N1 (33 vs. 16). Our interpretation is that having a similar lack of system knowledge, N1 and N3 had a different attitude toward the Web and learning. N1 was very hesitant and distrustful towards the quality of sources found in the Web whereas N3 had a more open attitude and she learned by trial-and-error using this strategy to explore the system features and reflecting on the small victories she achieved during the session.

Backward moves are an essential part of navigation in a hypertext environment. Novices used them more frequently than experts (40% vs. 24%) and in a different fashion. Experts used backward moves to navigate freely within the system whereas novices were obliged to use backward moves mostly due to the perception of lack of other alternative routes to search or to get out of an impasse. This interpretation is supported by the results of category Affect, where novices were trapped in labyrinths more often than experts (10 vs. 0).

Search engines: Novices scored lower than experts, that is, they used fewer search engines (5

vs. 7). This contrast was not only quantitative but also qualitative. Novices, with their more limited system knowledge and experience, had a more limited range of search engines to choose from. They could not access a search engine by typing its URL and often, as in the case of N3, accessed a search engine by chance using trial-and-error strategy. N3 accessed Yahoo indirectly by clicking on the legend that another user had compiled N3-E29. Furthermore, experts' choice of search engines was grounded on a variety of criteria such as the type of search they planned to follow (coarse vs. fine grain), the speed of access and response, and the organization of the search engine site. These choices were grounded in experience and prior system knowledge. Therefore, it is not surprising that experts used a higher number of search engines, covered a wider variety, and accessed them faster. For example, besides using Yahoo and Altavista, experts complemented their search with mega-search engines like Dogpile (EC-E159) or specialized ones such as an Education Search Engine (EB-E45). Being very familiar with their preferred search engines, experts knew their URL by heart and could access them directly. The total number of search engines used does not directly reflect in the scores of this subcategory because this information was coded in other categories such as Evaluation which is not presented in this paper.

The subcategory Direction of search was divided in three topics: 2.2.1 *Key words* included the number and the type of key words used during the search; 2.2.2 *FIND* feature included usage of the find key to look for a term in a site; and 2.2.3 *Advanced search* included usage of the search key, advanced search key, or refine key to either search for new sites or refine the present search. Overall, novices scored less than experts (28 vs. 34) in this subcategory.

One of the novice expert contrasts was found in the *Key words* topic (21 vs. 14). None of the participants used synonyms probably due to the lack of domain knowledge. Both groups used several combinations of the search term, *inquiry based instruction* adding social studies or upper elementary. In addition to using common key words, each group also employed different terms. Among novices, the terms *AERA* (N1) and *bibliography* (N2) were used. Within experts, EB added *research on IBI* and *history*. EA was the only one who used only one search term, *inquiry based instruction* and spent the rest of his time sifting through results. Regarding the use of quotations, N3 never used them as a way of

narrowing down the search, N1 and N2 used them sparingly; whereas experts always put their search strings in quotations. N3's limited system knowledge was also reflected in a lack of knowledge of where to type the key word IBI. For example, she wrongly typed it after the URL of McGill homepage in the address location.

By far the largest contrast between novices and experts was seen in the usage of the *find* key (1 vs. 11). N2 was the only novice who used this feature whereas all experts, especially EA used it frequently. This result is in line with the novices' lack of system knowledge and lack of self-trust in applying what they know.

In the *advanced search* topic, novices scored lower than experts (6 vs. 9). N3 and EB had the highest scores, which is consistent with their high degree of interactivity with the system. N3 spent a lot of time trying to narrow down her search because she believed that one has to read all the list of hits. She explored the results of her search only when she thought they were manageable, almost at the end of the search (episode117, out of total of 146 episodes). Experts, on the other hand, would read only the first couple of pages of hits. When they see repetitious sites, they would either modify the search string and/or change search engines or quit the search.

Sites visited by the participants varied greatly. Novices visited a total of 45 sites whereas experts visited 85. There were 9 sites (7% of the total) that were shared by some participants and skipped by others. Some interesting patterns emerged out of the analysis of these sites (Table 2.). In terms of grouping, N3 was the only participant who did not share any of the sites visited by the others. Two sites were visited by all experts (Critical thinking in an on-line world and Prufrock) whereas there was not a single site visited by all novices In terms of evaluation, the criteria used most often by novices was authorship (N1-E22). Authorship (EA-E119) was also frequently used by experts but they complemented it with other criteria such as currency (EC-E137), and accuracy (EB-E176). When some sites were evaluated differently, the discrepancy was among experts. Furthermore, shared sites did not imply been equally judged. For example, Prufrock was a publisher site and EA figured "these people sell books and I am interested in articles" so he would not pursue it, EB was turned off by the site's offer of "free catalogues" and EC was the only one who cautiously read more and thought it "could be

helpful". "Cow eyes dissection" was considered by EA as "... too applied and not theoretical enough" to warrant the visit whereas EB thought that it was "neat and he would definitely visit it". "Great Penny experience" was also visited by two experts and judged differently: EB disliked it, arguing that "...it did not seem to be research" whereas EC recognized that "it wasn't academic but still was interesting" and wished to get in touch with the author. Another interesting point is that in both instances of shared sites, novices' evaluation was the same as experts'. For example, "iWonder", was visited by N2 and EB. N2 was impressed as well as EB who considered it as an "interesting place to be". "Project based learning" was visited by N1 and EA and both evaluated it positively because of its "similarity" to the topic of search.

In sum, taking into consideration that experts used similar search engines and key words, only 2 sites out of 130 (less than 2%) were shared by all of them and only 7 out of 130 (or 5%) sites were visited by at least 2 of the experts. This finding could be explained by the fact that the Web offers users a huge number of alternative routes to take.

The subcategory of Waiting includes two topics: 2.3.1 *comments and actions* while the user is waiting for the response from the system; and 2.3.2 *accessing more than one search engine* simultaneously. Overall, novices scored less than experts (10 vs. 31) in this subcategory. While waiting, novices were more patient and made fewer comments than experts, probably due to their limited system knowledge and expectations from the Web. Experts not only made more comments but also employed several strategies to deal with waiting such as: a) considering not waiting more than 30 seconds, b) opening another browser while waiting for the response from the first one (EB), c) reloading or refreshing the page, and d) walking away to read a book, stretch or have a coffee.

2. Metacognitive strategies

This category included two subcategories: 4.1 reflection and 4.2 monitoring. Overall novices scored less than experts (33 vs. 47). Being that all the participants were graduate students, their metacognitive strategies were relatively high (41% and 59%). However, novices as compared to experts scored similarly in reflection (29 vs. 23) but lower in monitoring (4 vs. 24).

Reflection: This subcategory was subdivided in 5 subtopics: 4.1.1 *reflecting on the structure of the paper*; 4.1.2. *reflecting positively* on their knowledge; 4.1.3 *reflecting negatively* on their knowledge, 4.1.4 *reflecting on expert-novice differences*; and 4.1.5 *reflecting on the process of verbal protocols*. Overall novices reflected more often than experts (29 vs. 23).

In *reflecting on the structure of the paper*, since writing research papers is a common requirement for graduate level, it is not surprising that all participants reflected on linking search results with the structure of the paper (5 vs. 6).

In *reflecting positively about their knowledge, ability and interests*, novices scored higher than experts (6 vs. 3). This difference Probably emerged from the fact that experts did not express their positive feelings about their own knowledge and ability because they take it for granted. N2 (E35) reflected on his transfer of knowledge, and N3 (E90, E105, and E118) openly expressed her satisfaction with herself every time she managed to narrow down the search through trial-and-error. "...Yes, 198 matches, that's good, so I'm happy, so now I realize that I was doing something wrong, I was not clicking on every single subject, so now I know that the next time I do this, I have to address every single one" (N3-E118). EA, the only one who scored, reflected on his own knowledge and way of thinking. For example, he said: "you'll notice that my technique in problem solving is totally non-linear... I think in bursts...I can think of five trains of thoughts at the same time" (EA-E128).

In *reflecting negatively about their knowledge, ability and interests*, novices scored higher than experts (16 vs. 4 or 55% vs. 17%). This contrast could be explained by the fact that novices reflected frequently on their lack of knowledge about the system whereas experts reflected negatively on their own way of thinking. For example, N1who scored the highest in this topic (75%) said " It's probably just because I don't know where to go...it's more a failure on my part than on how the Web is organized" (E 117). Among the experts, expert B, who scored the highest in this subcategory (75%), said " I try to keep it organized but I end up, you know, my brain goes all over the place and doesn't always come up the way I want it to " (E172). Overall, novices spent 36% of their metacognitive sites in reflection vs. 28% for experts.

From the participant's perspective, *reflecting on expert-novice differences* was not a crucial

topic to reflect on. In fact, both groups scored low (1 vs. 2). For example, N2 reflected on himself as being a novice (E63). EA reflected on how novices don't know what they want when searching the Web (E126).

The process of *verbal protocol* itself was not a crucial topic to reflect on. In fact, novices scored lower than experts (0 vs. 5). Being the most articulated one of the three, EA reflected spontaneously on his experience of using the verbal protocols method during the cognitive task analysis. For example, he said, "These would've taken about two seconds... but because I'm verbalizing it, it's taking a bit longer" (EA-E26).

Monitoring: This subcategory includes two topics: 4.2 *monitoring the search* and 4.2.1 *timing*. Overall novices scored significantly lower than experts (4 vs. 24), which represents 5% and 30% respectively of the category metacognition.

In *monitoring the search*, novices scored lower than experts (2 vs. 8). Some examples of keeping finger on pulse of how the search is going are as follows. N2 said "At the moment, I haven't learned that much...I guess a good strategy would be to get an understanding of the subject...let me read the description here" (E71). EC was aware of going off track by saying, "Let's look at Terk papers... now we're going a little bit away from what we're doing we're just kind of fooling around..." (E126).

The most important novice-expert difference was found in the topic of *timing*, defined in terms of the stage of the search at which, the participant understands the meaning of the unfamiliar search topic or IBI. Novices scored lower than experts (2 vs. 16). This contrast was twofold, not only quantitative but also qualitative, that is, how many times and at what stage of the search they verbalized their understanding of the topic to search. N2 was the only novice who monitored the understanding of IBI by saying in the last quarter of the search "so again I'm realizing that a lot of the inquiry based learning seems to be in the domain of science education or math education" (E113). On the other hand, EC in the first quarter of his search, said "...now what I found curious is that most of the information we're finding about IBI deals with the sciences "(E40). The conclusion here is not that the meaning of IBI was out of reach for novices. Rather it is assumed that their working memory was overloaded with figuring out how to navigate and manipulate the system. Within experts, an interesting contrast

emerged. EA scored the highest (10), which is consistent with his profile as an articulate and reflective person, who planned and implemented a coarse grain analysis focused on understanding the meaning of the topic to search. Halfway through his search, EA said "...so I am reconstructing my idea of what inquiry based instruction includes...student-centered, student directed, teachers as pure mentors...so now I have some starting points anyway, before I was totally in the dark!" (E103). On the other hand, EB, despite having the highest number of episodes (217), using the highest number of search engines (5) and having two browsers opened simultaneously, was more tentative in grasping the meaning of the search topic. EB recognized that: "I am not a hundred percent sure but I have a pretty good idea...like problem solving but not quite problem solving...may be that maybe that's part of my problem..." (E79).

3. Affect

The category Affect was subdivided into five subcategories: 3.1 labyrinth, 3.2 unfulfilled expectations, and three types of feelings or attitudes during the search: 3.3 neutral, 3.3.1 positive and 3.3.2 negative. Regarding these three types of feelings, it is important to note that it is difficult to isolate them because they are interwoven with other categories, especially with a) positive and negative reflections on one's knowledge (4.1.2 and 4.1.3) which was already analyzed on in this paper, and with b) participants' satisfaction about intermediate and final results (1.5. and 1.6) that will be reported in a subsequent paper.

What really differentiated novices from experts is represented in the subcategory labyrinth. Novices were caught in labyrinths 10 times whereas experts never crossed that path. For example, among novices, N3 was the one who was caught most often in labyrinths (6 times). She started early during the search (E4) where she said "...just trying to figure out where I am..." Later on she added: "...I'm stuck, I don't know what to do next..." (E26).

During the search, novices and experts experienced unfulfilled expectations in a similar way (11 vs. 10). Within novices the scores in this subcategory were evenly distributed whereas among experts, 70% of the unfulfilled expectations were concentrated on EB. Three types of unfulfilled expectations were identified: The first was triggered by lack of specific features in a site like dead links (N2-E79),

no search keys within a site (EA-E56; EB-E83), and restricted access to sources in a hypertext structure (EB-85). Both novices and experts experienced this type of unfulfilled expectation, which was an immediate affective reaction to not being able to manipulate the system as expected. Being in the wrong location triggered the second type of unfulfilled expectation. This type was typical of novices. Within novices, N3 was the only one who verbalized her disappointment of repeatedly finding herself in the wrong spot, namely in the neighbourhood of math instead of social sciences (E95, E113, E125). Finally, wrong assumptions about the search topic triggered unfulfilled expectations. This type of unfulfilled expectation was more important than the others because it had a long-term impact by directly steering the direction of the search. EB erroneously associated inquiry based instruction with instructional technology that resulted in changing the direction of his search and finding irrelevant sites. For example, he was side-tracked by the idea that the University of Wisconsin, which he perceived as having a good reputation in instructional technology, could provide a good point of entry into research on IBI (EB-E108).

Novices scored lower than experts (3 vs. 5) in verbalizing their neutral feelings. The interesting point is that each group had different neutral feelings. N3 was the only novice who scored in this topic. She expressed being surprised that a course outline on the Web could present so much detail (E-136) or being puzzled at " finding the same search already written there..." (E-66) or being curious about some new features to explore (E142). Feelings of surprise, puzzlement and curiosity found in N3 contrasted with experts' feelings of being in control and not getting personally involved with the search results, which reflects the experts familiarity with the medium and the task at hand. This attitude was reflected in feeling at ease with the technology (EB-E1) and indifferent about not having found the right point of entry expressed as "I'm not frustrated, I'm also not optimistic, I'm just indifferent because this happens all the time. You have to try different points of entry" (EA-E35). Self-regulation practiced by experts avoid "frustration and circular problem solving...people get headaches...people complain of you know... this fuzzy feeling in their head that they can't describe and I just I don't even get involved with that. If I don't find what I don't want eh...then I just walk away from it" (EA-183).

Novices scored higher than experts (1 vs. 0) in expressing their positive feelings during the search. This low score in both groups might be due to a methodological issue. Those positive feelings about the results of the search during and at the end of the search were coded in another subcategory in the evaluation category that will be reported in a subsequent paper. The only example for N2 of positive feelings about the system is "Ok, Ok. So this seems to be working. Good, so we've got somewhere. (E-21).

Novices scored lower than experts (3 vs. 7) in expressing their negative feelings during the search (3.3.2). This, at first could be surprising. However, our interpretation is that part of novices' negative feelings were coded either in the subcategory 4.1.3, negative reflections on one's knowledge and ability, that was already analyzed in this paper, or in the subcategory 1.5 and 1.6 that reflected their in satisfaction about intermediate and final results that will be reported in a subsequent paper. Novices' negative feelings reflected anger about a feature of the system or feeling helpless for not knowing how to get out of a labyrinth. For example, on two occasions N2 said: "and again this stupid menu thing is kind of annoying..." (N2-E38 & E-97). N3 said "I feel kind of silly because I couldn't get out of that first area...I feel little yeah I feel a little like I was at a loss because I didn't know how to get out there, get out of that first section until I clicked on Altavista" (N3-147). Most of the experts' negative feelings (4 out of 6) dealt with their impatience during the waiting. As expressed by EB "It is a little frustrating having to wait" (E117). EC described his extreme frustration in naming the WWW as "oh...yak it is like the worldwide wait" (E111). Experts were more impatient with the waiting than novices. However, the frustration that they ventilated about the system did not impact negatively on their search. The fact that the experts were able to continue their search unaffected is likely due to their prior experience with this type of situations. Novices, were more patient with the system while waiting perhaps because having more limited system knowledge, their expectations about the system were lower.

Conclusions and Discussion

This study explored what type of affect and strategies expert and novice Web-users employed while searching the Web. Together with other studies, (Hill and Hannafin, 1997), our results confirm

the fact that it is crucial to apply navigating and metacognitive strategies in order to retrieve and evaluate information on the Web. These types of strategies and the importance of investigating feelings and attitudes during the search are confirmed by Marchionini (1995), as they are included in his model of Personal Information Infrastructure. As reported by Rumpradit (1998) study, experts and novices differed in the use of navigational due to their varying degrees of system knowledge that influenced the type and application of navigational strategies. Experts had a more in-depth understanding of navigational strategies. This was reflected in: a) the fewer number of moves and specifically of backwards moves; b) the higher number of search engines used; c) the direct access to search engines; d) the quality of sources found, and f) the use of more efficient search strategies such as the FIND. On the other hand, novices who had a lower system knowledge engaged in lower level search strategies as reported in other similar studies (Hill & Hannafin, 1997) and studies that included both print and electronic sources (Hansen, 1986). The novices lacked system knowledge about alternative search engines to use, how to refine a search and how to efficiently browse through a source. Among our novices, N3 frequently refined the search in much the same way as 3rd graders using a CD-ROM, who instead of examining the sources, preferred to refine and pose queries to the system (Marchionini, 1989). In our study, EA employed only one keyword and spent the rest of his time examining the results of his search in a manner similar to the more advanced sixth graders using a CD-ROM. Therefore, we can conclude that high degree of search refinement is not a strong indicator of successful retrieval of information.

None of our participants were familiar with the search topic and hence none of them used synonyms. In this study, EB used 7 key words whereas EA used only one. The former was the least successful in the search compared to the other experts. This result confirms the fact that the number of key words used during the search is not a strong indicator of success or failure (Hill & Hannafin 1997). This study also indicates that novices used backward moves more often than experts. This is confirmed by a similar empirical study (Rumpradit, 1998) where novices to get out of trouble used the backtracking facility more frequently.

In the subcategory monitoring strategies, the inability of novices to grasp and to verbalize the meaning of IBI (topic 4.2.1) confirms the findings of Hill and Hannafin's study (1997). Based on Ausubel (1963), these authors explain that their novices, despite being familiar with the search topic, had difficulties in relating new information to their prior knowledge. In the present study, in which all participants were unfamiliar with the search topic, the majority of novices did not integrate and transform their knowledge about IBI, which resulted in overlooking relevant information. This is reflected in two results: a) novices visited a lower number of relevant sites (18 vs. 39) and b) the low number of relevant sites shared with experts (Table 2).

In terms of affect, despite being impatient towards the slow pace of downloading, experts' attitudes were more relaxed, confident, and satisfied with their web search results. Whereas the unknown territory made the novices hesitant, the experts considered obstacles found during the information search as business as usual. Experts remained in control of the situation by monitoring their search and limiting information overload by browsing only the first couple of pages of the results; then, after evaluating the relevance of the sites, decided on a further course of action. Novices instead experienced disorientation and frustration when they were trapped into labyrinths. This reaction corresponds to the disorientation experienced in different degree by all novices in Hill and Hannafin's (1997) study. At what stage does disorientation becomes debilitating and hence a barrier for learning and continuing the Web search? In order to answer this question more research is needed. In our study, a strategy N3 used to get out of the long labyrinth where she had been stuck since the beginning of the search, was clicking all the features on the screen. This was consistent with N3's learning style by trial and error.

Marchionini (1995) states, "Electronically augmented personal information infrastructures affect us physically, cognitively and emotionally" (p.16). Our experts generally did not feel physical discomfort after spending up to 6 or 7 hours on the Web, whereas novices usually were tired after approximately one hour and a half. The common thread among all novices was a certain degree of frustration due to their lack of knowledge about search engines, and methods to narrow down the search.

Marchionini (1995) argues that besides "amplifying and augmenting our cognitive activity, electronic technology affects our metacognitive activity by changing our expectations...Novices often expect that information obtained from a computer will be more exhaustive and more accurate" (p.15). In the present study, this attitude was found both in experts and novices. However, the reaction to unfulfilled expectations caused disappointment in novices and impatience among experts.

In this study, the participants conducted the search using browsing strategies defined as:

> "An approach to information seeking that is informal and opportunistic and depends heavily on the information environment...(p.100). Browsing is particularly effective for information problems that are ill-defined or interdisciplinary and when the goal of information seeking is to gather an overview about a topic or to keep abreast of developments in a field" (Marchionini, 1995 p.103).

In the present study, browsing strategies matched the ill-defined nature of the search topic, and the participant's lack of knowledge of IBI. However, novices and experts employed browsing strategies differently. Novice's perceptual abilities for recognizing relevant information and deriving a definition of IBI were limited by the fact that part of their cognitive resources were devoted to solving major and minor problems in manipulating the system. Experts, who were in control of the manipulation of the system, could simultaneously use their cognitive resources to gain an overview of the topic in order to define IBI and to develop a plan to filter the information. For example, EA clearly articulated his plan to conduct a "...generic search to get a coarse grain analysis of the topic" in order to get a feeling of the topic to search (E4). Within experts we found a similar browsing style between EA and EC. They both articulated a plan for each step of the search. They could integrate new information and quickly obtain an approximate definition of the unknown topic of IBI. On the other hand, EB had a different way of browsing. His distinctive feature was a higher interactivity with the system. Allan Collins (1996) argues that high interactivity with electronic learning environments might limit thoughtfulness "...because things move fast, and a lack of problem finding and construction by students because

everything they do is responsive to some situation" (p. 352). Our hunch is that EB's high interactivity might have limited his ability to integrate new knowledge, thus impairing his ability to define the search topic and to steer the search in the right direction. Although these results were obtained from a small sample and should not be over generalized, they are promising and appear to be an important area for further research in adult literacy programs using technology (Wagner, D.A. & Venezhy, 1999). Future replications of this study should include a larger sample size, participants should practice thinking aloud before the cognitive task analysis, and pre-post measures should be used to measure participants' self efficacy.

Implications

In addition to exploring expert novice differences on the cognitive and affective dimensions of Web searching, this study attempts to raise critical issues on the use of the Web and to identify expert-novice differences that might have significant instructional implications for educators and designers. Some implications of our findings are: (a) critical thinking skills have to be taught in order to evaluate multiple sources of the Web (Rath, 1997); (b) encourage using metaphorical knowledge to map the problem mentally or graphically; (c) in order to avoid getting lost in cyberspace, cognitive and metacognitive strategies including browsing, concept maps and self-regulation (Corno, 1986; Winne, 1997) should be taught and modeled not only by teachers but also by librarians and computer savvy students (Warmkessel & McCade, 1997); (d) exposure to the Web should be done gradually to avoid tiredness and frustration; e) identifying the user's personal biases about the Web might prevent negative feelings and attitudes during the search f) using the Web as a research tool raises important issues regarding the validity and reliability of sources. For example, the exact conditions of this study are not easily reproduced due to the dynamic and changing nature of the Web. Change occurs not only in the number and type of features offered to the user but also the number and type of sources. Sites referenced one day could disappear the next.

Going beyond the fascination surrounding the use of the Web and in order to employ the Web to enhance knowledge construction, this study has emphasized that searching information on the Web is a complex phenomenon that requires developing a Personal Information Structure. This conclusion opens up multiple challenges for the user, the instructor, the librarian, and the researcher. Despite its limitations, it is hoped that this study has highlighted some issues that will contribute to the scarcity of descriptive classroom-based research focused on Web-based instruction.

APPENDIX

Table : List of categories and scores for all novices and experts

Category	N1	N2	N3	Tot Nov.	EA	EB	EC	Tot Exp	TOTAL
1. Navigational strategies	**24**	**35**	**51**	**110**	**51**	**62**	**39**	**152**	**262**
2.1 Moves					1			1	
2.1.1 Backward Moves	8	10	10	28	9	9	4	22	
2.1.2 Ser engines 2nd time		1	1	2	1			1	
2.1.3 Search engines	1	2	2	5	2	2	3		
2.1.4 Scanning,clicking	6	9	17	32	17	17	11	45	
2.1.5 Bookmarking		1		1	1	1		2	
2.1.6 Open favourites'list									
2.1.7 Copy-paste									
2.1.8 Direct access to site/s.engine	1			1		3	4	7	
2.1.9 Refine, refresh,re-load page			3	3	1		1	2	
Total subcat. Moves	16	23	33	72	32	32	23	87	159
2.2 Direction of search									
2.2.1 Key words	5	6	10	21	1	7	6	14	
2.2.2 Use FIND feature		1		1	7	1	3	11	
2.2.3 Advanced search keys	1	1	4	6	2	5	2	9	
Total subcat. Direction of search	6	8	14	28	10	13	11	34	62
2.3 Waiting		4	4	8	8	10		18	
2.3.1 Comments & actions	2			2	1	1	5	7	
2.3.2 Access > 1 browsers simult.						6		6	
Total subcat. Waiting	2	4	4	10	9	17	5	31	41
2. Affect	**4**	**8**	**8**	**20**	**18**	**34**	**10**	**62**	**82**
3.1Labyrinth	2	2	6	10					
3.2 Unfulfilled expectations	4	3	4	11	1	7	2	10	
3.3 Neutral feelings			3	3	2	2	1	5	
3.3.1Positive feelings		1		1					
3.3.2 Negative feelings		2	1	3	2	3	2	7	
3. Metacognitive Strategies	**15**	**12**	**6**	**33**	**24**	**16**	**7**	**47**	**80**
4.1 Reflection			1	1		3		3	
4.1.1 On structure of paper	3	2		5	2	4		6	
4.1.2 Positively ones' knowl, ability		2	4	6	3				
4.1.3 Negatively ones' knowl, ability	12	3	1	16		3	1	4	
4.1.4 expert-novice differences		1		1	2			2	
4.1.5 Verbal Protocol process					5			5	

Total subcategory Reflection	15	8	6	29	12	10	1	23	52
4.2 Monitoring		2		2	2	5	1	8	
4.2.1 Timing		2		2	10	1	5	16	
Total subcategory Monitoring		4		4	12	6	6	24	28

Table 2. List of sites shared among some participants and missed by others

NAMES OF SITES	SHARED AMONG PARTICIPANTS	MISSED BY PARTICIPANTS
Cow eyes dissection	EA and EB	EC & all novices
Great Penny experience	EB & EC	EA & all novices
FHSU K-3F	EB & EC	EA & all novices
NYSSI	N2, EA, EC	N3 & EB
Project based learning	N1 & EA	N2, N3, EB,EC
Prufrock	All experts	All novices
Ready to learn overview	EA, EC	EB & all novices

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