

Searching Microsoft Encarta 98: Using Think Alouds and Think Afters to Obtain Information-Seeking Processes Data

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A pilot study was carried out with five participants to compare retrospective and concurrent verbal protocols (Think Afters and Think Alouds) as methodologies for the study of the information-seeking processes of 12-15 year old students using Microsoft Encarta 98. After a short training session in the Think Aloud Method, four activities of differing complexity were completed by the participants. The data provided support for the use of verbal protocol analysis to uncover information-seeking processes of 12-15 year old students. The amount of data generated during Think Alouds and Think Afters depended on the difficulty of the questions and the number of "dead ends" encountered by the students. The Think Alouds and Think Afters provided data about the behavioural, cognitive processes while the Think Alouds also provided data about the affective processes. The study showed that Think Afters provide different data than the Think Alouds and so both are very important to understanding how adolescents interact with CD-ROM encyclopedias. Participants had mixed opinions on which method, Think Alouds or Think Afters, they preferred. However, all students seemed to speak openly and comfortably with the researcher in both methods. The data provided information about how effective reading strategies are very important to successful location and evaluation of information in CD-ROM encyclopedias. Participants were able to find the information to answer each of the four search activity questions but used a variety of search terms, categories and strategies. Some participants reached a level of frustration after a number of "dead ends" and needed encouragement from the researcher. The frustration was more apparent in the younger participants.

INTRODUCTION

The search for information by young people has become dependent on technology such as computers, CD-ROMs and the Internet. Yet, we know very little about the cognitive processes used to access information using these new technologies. How do we gather information about the cognitive processes that adolescents use in navigating through new technologies, specifically CD-ROM encyclopedias? One very useful way of studying cognitive processes is the verbal protocol analysis method.

Verbal protocol analysis is a methodology that is frequently used in cognitive psychology and education. The use of this method use in library and information studies, however, is still very limited. Verbal protocol analysis aims to find cognitive processes while solving a problem. According to Larkin and Rainard (1984), "a simple and powerful way to get such data is simply to ask a person to do the task and to talk aloud about all thoughts that occur" (p.236). Verbal protocols provide wonderful insights into the processes that people use when solving problems (Russo, Johnson, and Stephens, 1989).

Ericsson and Simon (1984) present concurrent and retrospective verbal protocols as ways to generate data about cognitive processes. Controversy exists, however, about the validity of both retrospective and concurrent protocols. Ericsson and Simon (1984) contend that both methods have validity depending on the

nature of the task. Their studies and others have indicated that there may be invalid or incomplete memory errors or interpretation by the participants who use the retrospective method. Concurrent verbal protocols have also been seen to cause problems when the task involves a high cognitive load, when the information is difficult to verbalize because of its form, i.e., visual data, or when the processes are automatic for the participants.

This paper explores the use of both concurrent and retrospective verbal protocols, Think Alouds and Think Afters, in a study of the information-seeking processes of early adolescents accessing information from CD-ROM encyclopedias. The study demonstrated the benefits and limitations of using these methods to understand the information-seeking processes of 12-15 year old students. However, it should be remembered that children and adolescents are not the only novice users of information technology. According to Chelton and Thomas (1999), "considering the problems of youth in navigating increasingly sophisticated searching environments may be helpful to system designers, at the same time that they serve as cautionary guideposts to those who may have forgotten the problems that exist for novice users of all ages" (pp. 7-8).

STATEMENT OF THE PROBLEM

The objective of this research was to analyse the effectiveness of the two methods, concurrent and retrospective verbal protocols, in obtaining information about the processes that 12-15 year olds follow in searching for information on Microsoft Encarta 98. Specific research questions were:

1. **What amount and detail of data were generated during concurrent verbal protocols?**
2. **What amount and detail of data were generated during retrospective verbal protocols?**
3. **How were the data similar and how were they different?**
4. **Which data provided the most complete and detailed description of the information seeking process?**
5. **Were both kinds of data useful?**
6. **Was one method more comfortable for the participants?**
7. **What did the data tell the researcher about the information seeking process of 12-15 year old students?**

LITERATURE REVIEW

Verbal Protocol Analysis

Verbal protocol analysis is a way to gain information about the cognitive processes of a participant's internal states using verbal reports. Verbal reporting is bringing thoughts into consciousness, making the ideas verbal if needed and then verbalizing them (Ericsson and Simon, 1984). Two types of verbal reports have been determined to give the best information on cognitive processes. Concurrent verbal reports, the first type of verbal reporting, are also referred to as talk aloud, think aloud or thought listing techniques. Retrospective verbal reports, the second method, rely on gathering information after the task is completed. For this study, the concurrent verbal protocols were referred to as Think Alouds and the retrospective verbal protocols were referred to as Think Afters. Data gathered by protocol analysis can provide information to test hypotheses and models of behaviour (Ransdell, 1995). Protocols done properly, according to Russo, Johnson and Stephens (1989), report the thoughts of participants but do not explain them.

The verbal protocol analysis method is now accepted by a large part of the psychological scientific community and is being used in a variety of different research areas. Hayes and Flower (1983) and Ransdell (1995) have used it in research in the area of writing. Whitney and Budd (1996) used the method to study text comprehension and other researchers have used the method to study reading comprehension strategies. Murtaugh (1984) used verbal protocol analysis to study the grocery shopping decision-making process. Sullivan and Seiden (1995) assessed the online catalog user education needs using the method. Verbal protocol analysis has been used to look at chemistry, physics and math problem solving, development of expert systems and can provide diagnostic information for teachers. Cacioppo, von Hippel and Ernst (1997) cited the many uses of verbal protocol research in clinical and counselling psychology such as social phobia, snake phobia, test anxiety, social anxiety, romantic relationships and group therapy.

Verbal protocol analysis has begun to be used as a method in research into information-seeking behaviour. Shu Ching Yang (1997) used verbal protocol analysis and observation to study six cases of information seeking behaviour in university students as they accessed information in the Perseus Hypertext System. The researcher had her participants practice thinking aloud and then asked them to think aloud while working on the problem. Hughes, Packard and Pearson (1997) also used the think aloud method in looking at reading in a hypertext environment. They introduced the method to the participants using a video of other computer tasks so that the method was demonstrated without "suggesting strategies for using the intended target of research" (p. 5). Xie and Cool (1998) used think aloud to study end-user online searching. They found, through the use of this method, "much insight is gained into the problems encountered by searchers and the adaptive strategies they employ in such situations" (p. 329).

For qualitative researchers interested in getting a rich source of data, the verbal protocol analysis method is a wonderful choice. Wilson (1994) emphasized that inspiration can be gained from people's conscious thoughts. Pressley and Afflerbach (1995) expanded the idea by noting that "spoken language is the data used in protocol analysis and the richness and variability of language are the greatest assets and liabilities of the verbal reporting methodology" (p. 2). Concurrent verbal protocols have been better received over the years than retrospective verbal protocols according to Ericsson and Simon (1984). Many of the concerns about retrospective protocols focus around the problem of forgetting and fabrication. Think Afters, according to Russo, Johnson, and Stephens (1989), may also be influenced by a motivational shift. This shift can occur whenever people are informed they are being observed. Enhanced learning may occur in Think Afters when participants are given time to think about what they have been doing.

Ericsson and Simon (1984) based their work on verbal protocol analysis on the constructs of short-term and long-term memory from information-processing theory. They hypothesized that all human cognition is information processing and stated "that a cognitive process can be seen as a sequence of internal states successively transformed by a series of information processes" (p. 11). Long-term memory contains a vast amount of knowledge, both procedural and factual, that can be accessed. The way this information is organized is highly individual. Short-term memory, on the other hand, is extremely limited if the information is not acted upon. External stimulation and associations from long-term memory are the basis of short-term memory. According to Pressley and Afflerbach (1995), short-term memory can be quickly accessed and the contents

reported. It is this short-term memory that verbal reports tap. Ericsson and Simon (1984) used this conclusion to validate the think aloud data that was gathered earlier in the century and to promote its continued use today.

Information Seeking in Electronic Environments

Research in the broad area of human-computer interaction in Library and Information Science has focused on the online search (Chapman, 1981; Fidel & Soergel, 1983; Morehead & Rouse, 1983; Fidel, 1984) with respect to adult or university users. Online Public Access Catalog (OPAC) research has recently included studies about children (Borgman, 1986; Solomon, 1993) as well as continued research with respect to adult or university student users (Allen, 1991; Spink & Beatty, 1995). In the areas of information retrieval and information-seeking processes, the focus has also been on adult or university users (Kuhlthau, 1991; Ford & Ford, 1992) or final year high school students (Kuhlthau, 1988; Kuhlthau, 1993).

Children are the newest users of electronic storage and information retrieval systems. Information retrieval using computers and CD-ROMs was, for many years, limited to library specialists or, more recently, university students. With the availability of inexpensive computers, CD-ROM drives and electronic encyclopedias, more and more children have access to these tools. It is important, therefore, to look at the information-seeking processes that are necessary for all students, across a range of abilities, to successfully retrieve information.

The computer is now a part of school libraries and classrooms, yet "it is surprising how little research has been done at the nexus of libraries and education, addressing questions of how to automate libraries for children in ways consonant with their learning, cognitive development, and curriculum" (Borgman, Hirsch, Walter & Gallagher, 1995, p. 663). Therefore, it is timely to look at how children interact with electronic encyclopedias. Marchionini (1989) looked at the information-seeking strategies of novice users in a full-text electronic encyclopedia. Marchionini and Liebscher (1991) looked at systems and how they can be adapted to the searching needs of electronic encyclopedias. Perzylo and Oliver (1992) studied students interacting with *National Geographic Mammals* and found that the visual and auditory effects caused distractions. The work of Andrew Large and his colleagues (Large, Beheshti, Breuleux & Renaud 1996; 1995; 1994a; 1994b) at McGill University compared children's information retrieval in print and electronic encyclopedias. The electronic encyclopedias were adapted with a variety of animation sequences. The research in the area of CD-ROM encyclopedias included studies on children but the researchers have not dealt with the specific questions posed the study reported in this paper.

METHODOLOGY

Participants

The 5 participants in this study were between the ages of 12 and 15 and were in grades 7, 8 and 10. Three of the participants were boys and two of the participants were girls and all were identified as willing to participate through discussions with colleagues at the University of Alberta. As a result, this group was by no means a representative sample of the population. In fact, quite the opposite was true. In the initial interviews, it was revealed that all of the participants had computers at home. Their computers were equipped with CD-ROM

drives and each participant had CD-ROM encyclopedias at home. The participants came from academic families with one or both parents having university degrees.

Pretest

A pilot study with one participant took place at the researcher's home prior to the actual study. In that interview and observation, the participant completed the same search activities and answered the same interview questions. After the observation was complete, the participant was asked several additional questions about the design of the research. No changes to the study were made so the participant's interview and search activity results were used to look at all the research questions except the first two.

Procedures

The study took place in a lecture room in the School of Library and Information Studies at the University of Alberta one evening. Arrangements were made for the participants to meet the researcher at the university in one-hour intervals. The participants were welcomed and the permission and consent forms were collected. Information about the study was given and the participants were given the opportunity to ask questions and to withdraw at any time during the interview and observation. The room was set up with a laptop computer, a tape recorder and two chairs were placed in front of the computer. The participants were asked to answer the interview questions first and then the plan for the rest of the study was given. Participants had an opportunity to ask any questions at this point.

Participants were read a script describing the searching activities and were given the opportunity to practice the Think Alouds. See Appendix A for a copy of the interview and observation schedule. After completing the practice session, participants were introduced to Microsoft Encarta 98 and given an introduction to the searching capabilities of the electronic encyclopedia.

The participants then began the four search activities. The search activities were:

1. **Describe the male cardinal bird.**
2. **In what year was Queen Elizabeth II born?**
3. **What year was speed skating first in the Winter Olympics?**
4. **Who was the first woman in space?**

Each participant was required to search for the answers to the same four questions. However, each participant was asked the questions in a different order. Two of the search activities required two participants to do Think Alouds and two participants to do Think Afters. One search activity was done as Think Alouds and one search activity was done as Think Afters by all participants. To allow for differences in the amount of verbal reporting at the beginning and end of each of the participant's session, each search was done as the first, second, third and fourth activity.

The participants were encouraged to speak openly. The researcher did not interrupt unless specifically asked a question by the participant. No other person was in the room with the researcher and attempts were

made to limit distractions i.e. window blinds were closed and no extraneous materials were on the tables. The four searches were done one after another with no breaks in between. The final question, asked after the four search activities were complete, was which method, Think Alouds or Think Afters, the participant found most comfortable. Each complete session took about 30 minutes. After the session was completed, the participant was thanked for his or her participation and any further questions were answered.

FINDINGS

Amount of data in Think Alouds and Think Afters

Table 1: Total Number of Words used by Participant in Search Activities

Participant	Search Activity 1		Search Activity 2		Search Activity 3		Search Activity 4	
	Think After	Think Aloud	Think After	Think Aloud	Think After	Think Aloud	Think After	Think Aloud
B		20		31	131		73	
C		76	159		258			339
D		16		76	130		138	
E		71	24		88			1355

To determine the amount of data that was generated during Think Alouds and Think Afters, it is interesting to look at the number of words the participants used in each search activity. The number of words used to answer "Who was the first woman in space?" is shown in search activity 4. In this search activity, which the participants found to be the most difficult, many more words were used in doing the Think Alouds than the Think Afters. The participants answering "Tell me about the male cardinal" (search activity 1), used very few words in the Think Alouds. This question was the easiest one for the participants. Search activity 2 asked the participants to find out the year Queen Elizabeth II was born and the number of words was influenced by how easily the participants were able to find the answer to this question; participant C tried several different search terms before finding the answer. Search activity 3 asked participants to "Find out when speed skating was first in the Winter Olympics". This question was difficult and the participants hit several dead ends or had to read large amounts of text to find the answer. The large number of words required to do the Think Afters indicates the difficulties encountered when searching for the answer.

Detail, similarities and differences of data in Think Alouds and Think Afters

Similarities emerged in the detail of data generated by the two types of verbal protocols. The Think Alouds and the Think Afters provided information about the participant's cognitive and behavioural processes in finding the answers to the questions. Participant E described finding the answer to the speed skating question in a think after:

Well I typed in skating, no speed

And then I just like looked down and I found speed skating so I clicked on that but it was all on figure skating

And then

*So I saw a picture of a speed skater and I clicked on expand and I found that name
and so I made it smaller again
And then I was looking down here and I found speed skating and I clicked on that and
I read it and found the answer*

Participant B described finding the answer to search activity 1 in a think aloud:

*The male cardinal
Okay
Find cardinal
Cardinal
Bird
Okay
Ummm
Cardinal bird
Common name for several crested finches found in North, Central, and South
America. The best known is the 22-cm northern cardinal. Males of this species are of
various shades of red, depending on their subspecies, and have a black "mask" from
the eyes to the throat. Females and young of this species are buffy brown, with
touches of red on the crest, wings, tail, and breast.*

Similar data about search strategy and decision-making can be gathered from Think Alouds and Think Afters.

However, in the Think Alouds, much more detail about the affective nature of the information-seeking processes was also given. Participant D, in a talk aloud, described the search for the year Queen Elizabeth II was born:

*And I am clicking on Elizabeth queen consort
That was wrong
I clicked on the wrong thing
Now I am going to type in royalty
I clicked on the queen royalty
And I am clicking on England
And I am going to click on Elizabeth II
And she was born in 1926*

The Think Alouds more clearly provided the data about frustration during searches. Participant C's search to find the first woman in space clearly shows the beginnings of frustration at being unable to find the answer:

And again I am just skimming through here and this doesn't seem what I am looking for

*So I am going back to find
Okay
That wouldn't work
So I am typing in a famous astronaut that I do know of (Roberta Bondar)
It's not working
So I am just going down the list
And I am just looking down this column on the left hand side of the screen
Doesn't seem to be anything here so
Go back to find
And I am just going under physical science and technology and hopefully I will find
something here*

The Think Alouds also provided data about success and excitement in searches. Participant E described the search to find the first woman in space:

*Oh wait that was the wrong thing
Find again
Maybe I should do
Okay I'm scanning them down
I am going to do women in physical science
Ah ha
Astronauts
Yes I found it*

The Think Afters provided a "path of least resistance" approach to describing the information-seeking processes that the participants used in searching on Microsoft Encarta 98. Some of the participants forgot the dead ends and incorrect search terms in retrospectively describing the search process. These data are consistent with the work of Ericsson & Simon (1984) who found participants may forget information in retrospective verbal protocols. In doing the Think Afters, participants tended to describe the shortest route to finding the correct answer. This usually included the first search term and the final search term used but eliminated some of the dead ends that occurred in the middle of the search. With particularly difficult searches, like search activity 3, the participants found it difficult to remember their search. Participant B described his search to find the year speed skating was first in the Winter Olympics:

*I went up to the find
First I searched for Olympic Games
And I opened that article and I didn't find anything on speed skating so I went to find
again
And I put in speed skating and I went to ice skating and the first article on ice skating
Then I scrolled down to ummm history I think
No that's what I did I went to the left and clicked on speed skating*

*And then I went down to the history
Ummm til I found the paragraph where it mentions when they made their debut for
female and male in the Winter Olympics*

Participant A found it difficult to remember the search and tried using the back button feature on Microsoft Encarta to follow the path:

*And I typed find and I got a list of astronaut and it listed other women's names and
newspapers and mining
I didn't think any of them would really tell me in general which would be the first
woman astronaut.
As I scrolled down I saw a picture of Mae Jemison so I clicked on the caption and it
turned out she was the first African-American in space
Then I looked down it gave me a bunch of information on well Americans yes
And then under astronaut, I think
And then I went down to milestones
I can't find it again.*

The Think Alouds provided the most complete and detailed description of the information-seeking processes. Not only did Think Alouds provide the specific search terms and decision-making steps but they also allowed a glimpse into the affective nature of the information-seeking process as well. The points where decisions were made were also clear in the Think Alouds. Participant E's search for the first woman in space was an excellent example of the richness of data provided in Think Alouds:

*I am going to type in space travel I think because
Ohhhh I spelled it wrong
Space travel
Okay it doesn't match
So I am going to just go back to the beginning erase it and try again
Ummm Space
Space exploration that looks right
I just went down to space exploration
And I am just scanning what they have to say here
I'm just I'm scanning the titles
Right
I'm just going to go down because
Because none of these titles match what I want
Humans in space
Here we go
I am just reading what it says here
See if they have anything about women in space*

*Oh what does that say
Ummm nope
They don't have anything
I'm just reading the little side thing*

However, the reasons behind the decisions that were made were often explained in the Think Afters. For example, Participant D describes the reason behind a decision made during the woman in space search:

I knew I didn't want to type in Roberta Bondar because she is a Canadian.

Participant C described the process of selecting the appropriate search term in the Think Afters:

*What I started with was typing in the word queen to see if her name would be under that.
I saw a different list of things like queen bee, queen as in chess and then I skimmed down the list and I saw that there was only two names with Queen Elizabeth but they weren't the right ones that I was looking for
So then I typed in Queen Elizabeth and it gave me the two topics that I didn't need
And then I typed in queens and the word search box came up and gave me a list of countries of the queen I wanted*

Usefulness of Think Aloud and Think After data

Both kinds of data were useful. The Think Alouds provided the richness of data associated with verbal protocol analysis. Participant E's searching for the first woman in space, shown above, is a beautiful example of the complex data generated in Think Alouds. However, an example like the one from Participant C's search for the Queen Elizabeth II question shows the valuable data from Think Afters. For this type of research, where an understanding of adolescent's information-seeking processes using CD-ROM encyclopedias is desired, both methods are valuable and necessary.

Preferred method

When asked which method they preferred, Think Alouds or Think Afters, participants were mixed in their opinions. Several felt that it was easier to do Think Alouds because it was difficult to remember all the steps at the end of the search. Participant A preferred the Think Alouds because in "the think after you really had to go back and remember all the steps that you did". Participant C also preferred Think Alouds because it was easier "telling you (the researcher) what I did while I was doing it. It was easier to remember". However, two of the participants preferred the Think Afters. Participant B described the reason this way:

*Cause then I can focus on going through and finding something and then once I found it let you know afterwards
Cause if I go through and I get to a point where I know it is not going to be there then I have to go back and start again*

It is easier to tell you at the end

Participant E preferred Think Afters as well and explained the reason:

After I think because when I was doing it I got kind of absorbed in it and I was almost forgetting to tell you things.

Despite the differences in preferences, the researcher saw no differences in the extent to which participants spoke freely and openly in the study.

Information-seeking processes of 12-15 year old students

Table 2: List of Search Terms and Search Categories for Search Activity 4

Participant A	Participant B	Participant C	Participant D	Participant E
Used Wizard	Space	Space history	Women in space	Space travel
Physical science and technology	Space exploration	Roberta Bondar	Space exploration	Space exploration
Woman in space	Humans on the moon	Physical science and technology	Challenger	Women in space
Mae Jemison	Astronaut	Louis Armstrong	Woman's name	Women in science
Astronaut		Neil Armstrong		Employment of women
		Space exploration		Women in physical science
		Astronauts		Astronauts
				Female Astronauts
				Sally Ride

The transcripts of the Think Alouds and Think Afters provided some very interesting data about the information-seeking processes of 12-15 year old students. Refer to Table 2 to see an example of one search activity. It was fascinating to see students find the same answer in the CD-ROM encyclopedia using such different search terms and in such different ways. For search activity 4, the first woman in space, participants used a wide variety of approaches. Despite the wide variety of approaches, in the end each participant was able to find that Valentina Tereshkova was the first woman in space.

The participants demonstrated the importance of good reading strategies in searching in CD-ROM encyclopedias. Participant D described searching for the answer to the first woman in space activity:

*And I just went through pretty much everything
I went through pretty much everything in space exploration*

I didn't, I just kept on going until it said

Participant C described searching for the year speed skating was first in the Winter Olympics:

*And then I went to ice skating and then I skimmed through it
And I went to the topic speed skating
And then I read and then I read I read down the list and I finally came to a section
where it was talking about what years
Figure skating was included in the summer Olympics and I thought maybe that it
would give me a date for the Winter Olympics as well
And then I read the next few lines and I figured out that it was held first held in 1924*

Participant E described the different types of reading that she used when searching for the first woman in space:

*I'm just I'm scanning the titles
Right
I'm just going to go down because
Because none of these titles match what I want
Humans in space
Here we go
I am just reading what it says here
See if they have anything about women in space
Oh what does that say
Ummm nope
They don't have anything
I'm just reading the little side thing
Ummmm
No
History
I'm just scanning through here because I am looking for space propulsion*

All of the participants used skimming, scanning, speed-reading and focussed reading to locate and evaluate to determine if the information was correct. These reading strategies need to be taught to use print encyclopedias but it is also apparent that the same skills are necessary for successful use of CD-ROM encyclopedias.

The data also revealed much about the frustration that searchers experience in trying to locate information in CD-ROM encyclopedias. After several "dead ends", Participant C expressed frustration:

*That won't work
Space exploration
Now I look here again (?)*

*Milestones
Piloted space flights
This might give me something
Skip down here
I'm having a little trouble*

Participant E also showed some frustration at reaching a series of dead ends:

*No
Oh wait I am going to look on the left just see the titles
Incomes
So I am going to go back to find again
Ohhh
Shoot I shouldn't have done that
Okay I'll just write down women again like I did before because I lost what I did before
And I'll go down and see employment of women again
Oh wait that was the wrong thing
Find again
Maybe I should do
Okay I'm scanning them down*

The researcher was available in these situations to provide encouragement or perhaps the motivation to continue the search. In real-life situations the student might abandon the search at this point. It is interesting to note that it was the youngest participants who reached this level of frustration. In further studies it will be important to determine if this is generally true.

CONCLUSIONS

Summary of Findings

The data provided support for the use of verbal protocol analysis to uncover information-seeking processes of 12-15 year old students as they access information on Microsoft Encarta 98. The amount of data generated during Think Alouds and Think Afters depended on the difficulty of the questions and the number of "dead ends" encountered by the students. However, from the results of this small study it seems that Think Alouds produce more words only during a difficult search activity. Both thinks alouds and Think Afters provide useful data. The Think Alouds provide data about the behavioural, cognitive and affective processes that the students use in searching in the CD-ROM encyclopedias. The Think Afters provide data about the behavioural and cognitive processes but little of the affective processes. The Think Afters provide different data than the Think Alouds and so both are very important to understanding how adolescents interact with CD-ROM encyclopedias.

Participants were mixed in their opinions on which method, Think Alouds or Think Afters, they preferred. However, all students seemed to speak openly and comfortable with the researcher in both methods. The data

provided information about how effective reading strategies are very important to successful location and evaluation of information in CD-ROM encyclopedias. Participants were able to find the information to answer each of the four search activity questions but used a variety of search terms, categories and strategies. Some participants reached a level of frustration after a number of "dead ends" and needed encouragement from the researcher. The frustration was very apparent in the younger participants.

Recommendations for Further Research

Verbal protocol analysis is a method often used in psychology and educational research. It has been used to look at problem solving in a variety of situations with success. In this situation, it generated a great amount of detailed data about the behavioural, cognitive and affective processes used by 12-15 year old students when searching for information on a CD-ROM encyclopedia. The think aloud and think after methods provide a way to gain a greater understanding of many aspects of the work of librarians in the field.

In this study, the Think Alouds and Think Afters were audiotaped while the students were using Microsoft Encarta 98. Three participants told the researcher that they experienced some difficulty in doing Think Afters because of forgetting. Ericsson and Simon (1984) noted that this can be a problem in some situations. To better allow students to describe their information-seeking processes, however, it seems that some other method of recording data is needed. This researcher believes that using videotapes of the search activities would be one way to increase the amount and detail of data in the Think Afters. The computer screen would be videotaped and after each search activity the videotape could be played back to enable participants to better remember their information-seeking processes. At this time, the researcher and the participant would be able to interact with the video and discuss the cognitive, affective and behavioural processes involved. The addition of the videotaping will be tried in a future study.

The last research question of this project is the research problem in the doctoral work of this researcher: What did the data tell the researcher about the information seeking process of 12-15 year old students? On reflection, this question was too broad to be covered in this small pilot study. Yet, in doing this study, many new questions have developed that need to be answered in order to gain an understanding of this research problem.

1. **How is the search activity question reframed in the participant's mind?**
2. **How does this reframing influence the initial search term?**
3. **How do participants recover from dead ends?**
4. **Does the age of the searcher affect the number of dead ends?**
5. **Does the age of the searcher influence the frustration level reached?**
6. **Do the Think Alouds and Think Afters influence future thinking about searching on CD-ROM encyclopedias?**
7. **How does the affective nature of the participant influence the search activity?**
8. **At what point(s) does the affective influence the cognitive processes during search activities?**

9. What similarities and differences are seen in the information-seeking processes during participant-generated topic searches and researcher-generated topic searches?
10. How does personal experience with CD-ROM and print encyclopedias influence the information-seeking processes?

In order to gain a deep understanding of the information-seeking processes of 12-15 students using CD-ROM encyclopedias, rich data need to be generated. Using both the retrospective and concurrent verbal protocols will provide the best data for understanding the specific processes involved. Marchionini (1995) at the end of *Information Seeking in Electronic Environments* stated that the design of systems to enhance the way people learn is very important. However, he pointed out that "we should pay more attention to the information-seeking process and the interactions among the information-seeking factors rather than the technology itself" (p. 196).

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