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EVALUATING THE EFFECTIVENESS OF A METACOGNITIVE TOOL ON EDUCATION GRADUATE STUDENTS' INFORMATION SEARCH BEHAVIOR IN DIGITAL LIBRARIES

By

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DISSERTATION APPROVAL PAGE

This is to certify that the dissertation prepared by Barbara Blummer

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has been approved by her committee as satisfactorily completing the dissertation requirements for the degree Doctorate of Education.

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ABSTRACT

Evaluating the effectiveness of a metacognitive tool on education graduate students' information search behavior in digital libraries

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This study evaluates the effectiveness of a tutorial in enhancing eight education graduate students' information searching in digital libraries for problem solving activities. The tool centered on "idea tactics" that expert searchers employ to "help improve their thinking and creative processes during searching" (Bates, 1979, p. 280). These tactics also represent metacognitive strategies and twelve of these concepts are incorporated in a tutorial to improve users' search strategies during a problem solving exercise. The mixed method study targeted education graduate students, an underserved population in library information seeking research (Earp, 2008, p.74). Quantitative measures were utilized to track participants' accesses to the tutorial components, number of revised searches and records examined, as well as time spent in the tutorial, devising search strategies and reviewing results. Scores comparing students' initial (pre-tutorial) search with their post-tutorial search were also considered. For the qualitative part of the research participants verbalized their actions as they located resources in the library's commercial databases. Follow-up interviews considered participants' satisfaction level with the results, the helpfulness of the tutorial, difficulties with the think aloud protocol, and any additional information they chose to offer. The research adopted two coding schemes for the transcripts including the use of pre-figured codes as well as an open

coding format. Reliability was enhanced through the availability of two individuals for the coding process. Overall, students benefited from the application of various idea tactics or metacognitive strategies to their problem solving in library databases that was illustrated in improved scores for their final search.

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I. INTRODUCTION

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Problem Statement

Academic library services provide research training to users. Traditional library training focused on students' information literacy skills and included instruction in utilizing advanced database features and searching relevant materials. However, some students still have difficulty locating resources following library training in database search techniques (Blummer, Lohnes, & Kenton, 2009). One novel approach to enhancing students' research techniques highlights individuals' information problem solving abilities and especially their metacognitive skills. This perspective views information problem solving (IPS) as a form of information literacy that requires students to employ metacognitive skills or the "ability to plan, monitor, and evaluate ones' own action" (Lazonder & Rouet, 2008, p. 759). IPS researchers equate information problem solving with information seeking in online databases and the web. Moreover, they note the importance of problem solving competencies in fostering students' success in academia and beyond (Walraven, Brand-Gruwel, & Boshuizen, 2008, p. 624). To this end, this dissertation studied the effectiveness of an idea tactic tutorial to enhance participants' information searching in digital libraries for problem solving activities. The tool centered on "idea tactics" that expert searchers employ to "help improve the

searching, thinking and creative processes during searching" (Bates, 1979, p. 280). Bates identified 17 tactics and nine of these concepts are incorporated in the idea tactics tutorial. Three additional tactics based on metacognitive strategies are included in the tool. This tutorial also contains definitions as well as examples and it was provided to participants in an online format during a problem solving exercise.

This chapter discusses the role of metacognition in problem solving during search as well as the lack of research on students' use of metacognition in information seeking. It also highlights the value of metacognitive scaffolds in problem solving and especially the use of online tutorials to deliver skills training.

Background – metacognition in information search

Research on information need, information behavior, and information retrieval highlighted the enormous cognitive demands placed on users during information seeking. Ellis (1989) and Kuhlthau (1991, 2004) suggested that users progress through various stages of information acquisition. Dervin (1983, 1992) maintained users aim to satisfy an information gap that exists between an individual's experiences and their knowledge. Marchionini (1995) highlighted users' efforts to assess the effectiveness of the information retrieval process especially "how it relates to accepting" the information need and the ability of the retrieved material to support the task (p. 58). Wilson (1999) emphasized the importance of feedback loops in information behavior models due to the "iterative" character of the process that produced "new research questions" (para. 70).

The cognitive demands on users are particularly excessive in searching digital libraries. Pomerantz, Abbas, and Mostafa (2009) defined digital libraries as a collection of electronic materials created, managed and organized by a user community who

provides technical and user services as well as adds value to the materials. Moreover, Fuhr et al. (2007) characterized digital libraries as "complex systems" that were under "constant development and change" (p. 21). In addition to the wealth of materials available to users, there are also numerous avenues to access items through search, filtering, and browsing techniques. These features coupled with variations in layout and navigation among various systems as well as labeling inconsistencies affect the usability of digital libraries (Hartson, Shivakumar, & Perez-Quinones, 2004). Xie and Cool (2009) documented the various types of help users seek in searching digital libraries that related to problems with getting started, identifying collections, creating search statements, refining searches, and evaluating results. They recommended that digital libraries include different types of retrieval knowledge such as "how to effectively construct a query, how to deal with no results, and how to deal with overwhelming results" (p. 491).

Some research suggests metacognition could enhance individuals' interactions in digital libraries. Marchionini (1995) pointed to the importance of metacognition in information seeking. He maintained that metacognition triggered our need for information, enabled "mental models for systems and domains," and monitored "our progress" (p. 14). Likewise, Gorrell, Eaglestone, Ford, Holdridge, and Madden (2009) noted the "emergence of interest in metacognition in the context of web search and online inquiry" (p. 447).

Recent studies focus on promoting students IPS skills particularly metacognitive strategies to support online search (Brand-Gruwel, Wopereis. & Vermetten, 2005; Walraven, Brand-Gruwel, & Boshuizen, 2009). Wopereis, Brand-Gruwel, and Vermetten (2008) illustrated the effectiveness of providing IPS instruction to distance

education students in a research methodologies course. This instruction focused on specific sub-skills within five categories including: define problem, search information, scan information, process information, and organize and present information. Pre-test and post-test results focused on how frequently a skill was performed by the experimental and control groups. According to the authors, the experimental group performed better following a pre-test and post-test of students IPS skills. Students receiving IPS instruction engaged in text scanning and information evaluation more often than those individuals in the control group. In addition, these students engaged in significantly more metacognitive activities compared to those in the control group.

Research on problem solving also underscored the role of metacognition in promoting favorable outcomes. Perkins and Salomon (1989) maintained metacognition supported the development of strategies for "problem solving, inventive thinking, decision making, learning and good mental management" (p. 17). Likewise, Flavell (1978) believed that it remained important to assist individuals in identifying their competencies and especially in teaching them how to utilize this knowledge appropriately. According to the author, young children could be instructed to harness their metacognitive abilities to enhance problem solving. The author suggested focusing on the "task features" such as the identification of the problem and any sub-problem, tracking "past solution efforts and outcomes, and considering other related information" (Flavell, 1978, p. 237).

Other theorists have recognized the significance of metacognition in facilitating individuals' problem solving skills. Sternberg's triarchic theory of intelligence pointed to the role of metacomponents in problem resolution by fostering the recognition and

definition of the problem, the gathering of "mental resources" for tackling the problem, the development of steps and strategies for problem solving, and support for monitoring the process and evaluating the solution (Sternberg & Frensch, 1990, p. 89). Frensch and Sternberg (1989) linked problem solving to an individual's flexibility in adapting his thought processes to the current situation. They promoted instruction in "learning to learn skills" (p. 183).

Need

Despite the importance of metacognitive abilities in influencing information search outcomes, there is minimal research on graduate students' metacognitive activities during information seeking for problem solving. Hess (1999) investigated one graduate student's cognitive processes during a web-based information retrieval session. He pointed to information overload as an obstacle for retrieving material and advocated training users in information skills, defined as the ability to "retrieve, filter, and store relevant information" as well as differentiate it from irrelevant material (p. 7).

While there is some research on the students' use of metacognitive interventions during problem solving, these studies are largely directed at elementary and undergraduate students. For example, Laxman (2010) reported on twenty-five freshmen students' successful use of an intervention to assist their information seeking in confronting well and ill-structured problems.

Still, research suggests these scaffolds offer potential to improve information processing for graduate students as well. Chen and Ge (2006) described the development of a web based cognitive modeling system to support ill-structured problem solving through question prompts, expert modeling, and peer review. This prototype system was

aimed at facilitating scaffolding for instructional technology graduate students in solving instructional design problems. The availability of a case library fostered students' abilities to "perform analysis" and "propose solutions" to instructional design problems (p. 300). In a pilot evaluation of the program, students indicated the system facilitated their abilities to utilize "prior knowledge, organize their thoughts, and articulate their reasoning" (p. 301).

Although there are an abundance of studies on the information seeking behaviors of various professional groups and undergraduate students, librarians have directed little effort to identifying the "research process of graduate students" (George et al., 2006, para. 6). This trend is especially pronounced among studies focused on education graduate students. Still, information seeking behavioral research supports the development of services and collections to targeted groups. Vezzosi (2008) emphasized the need to explore users' information seeking patterns to design and plan activities "tailored to users' learning needs" (p. 65).

A pilot study of Towson University's College of Education's master's students' information seeking behaviors, based on interviews and a survey, revealed that graduate students had feelings of confusion and uncertainty when researching (Blummer, Lohnes, & Kenton, 2009). Several interview participants reported difficulty determining when to stop gathering information as well as in creating the final product. In addition, some survey respondents expressed dissatisfaction with the content of their previous library instruction. The pilot suggested these graduate students were savvy searchers, but required instruction in techniques to enhance their ability to locate and process the volume of information on the web.

Problem solving, literacy in digital libraries, & tutorial based library instruction

Librarians differ over the most appropriate focus of information literacy instruction. Johnston and Webber (2003) believed instructional efforts in the United States suffered from a dependency on the Association of College & Research Libraries' definition of the information literate individual. According to the authors, their guidelines reduced "a complex set of skills and knowledge to small discrete units" (p. 337). Grafstein (2002) observed the information explosion called for an "understanding of the differences between knowledge and information" (p. 200). She pointed to the importance of prior knowledge in individuals' acquisition of new knowledge, their reading comprehension, as well as users' abilities to integrate various ideas. Likewise, Thelwall (2004) noted the importance of search skills in digital libraries and predicted that the next generation of scholars would require a new skill set to interact with research from a variety of disciplines. Bowler (2010) suggested librarians instruct students in "how to think about their own thinking" and especially using metacognitive knowledge to enhance problem solving (pp. 38-39).

Research also highlighted the value of tutorials in providing research skills to scholars. Ragains (1997) underscored the role of online and web based instructional guides and tutorials in his calls for "more aggressive proactive planning and delivery of instruction" (p. 160). According to the author, librarians required a variety of "ways to reach students" other than one shot course related faculty requested training (p. 168). Diekema, Holliday, and Leary (2011) reported on the success of an online information literacy tutorial that centered on problem based learning. The authors noted some

participants employed metacognitive strategies that focused on “using information to learn, rather than finding sources (p. 267).

Consequently, idea tactics are utilized as a metacognitive intervention to support education graduate students’ information problem solving in digital libraries. These tactics represent search strategies used by information specialists and compiled by Bates (1979) to “help generate new ideas or solutions to problems in information searching.” She described the tactics as part of a “facilitation model” that may help the searcher in an online or print environment (p. 280). In this instance the tactics are presented in a tutorial and the study measures the impact of the intervention on participants’ search strategies and their search outcomes. Table 1 lists nine of these tactics and includes three additional strategies designed to promote individuals’ metacognitive skills. An initial search served as a pre-test that illustrated participants’ problem solving strategies and database search skills. This information was compared with strategies and search techniques participants demonstrated following access to the tutorial.

The value of metacognition in promoting favorable outcomes in information search cannot be overstated. Consequently, this research examines the role of metacognition in facilitating information problem solving in digital libraries.

Table 1

Idea Tactics in the Metacognitive Tutorial

Tactic	Description
Think	Identify search goals or what you wish to accomplish.
Catch	Recognize an unproductive search and instigate a new approach.
Notice	Consider the appearance of any clues that may affect your interpretation of the question or how to answer it.
Meditate	Analyze the search strategy by incorporating scientific as well as intuitive thought processes for problem solving. This is often described as convergent and divergent thinking. Individuals typically employ one or the other in developing solutions. However, some researchers claim creative problem solving involves both modes of thought.
Change	Instigate a new search behavior, a different keyword, source, or strategy.
Create	Develop a search strategy by identifying relevant keywords, search fields, and databases to access. Research suggests expert searchers adopt a plan rather than follow trial and error techniques.
Wander	Examine the sources for indications of new source opportunities and avenues.
Jolt	Move out of conventional thought patterns to view the source in an unconventional way.
Identify	Determine personal and system knowledge that may improve search results.
Break	Change standard search habits.
Regulate	Pay attention to your thought processes as well as how you structure the search process.
Skip	Explore the topic from a different perspective or tackle another component of a multipart query.

Note. Adapted from "Idea Tactics," by M. Bates, 1979, *Journal of the American Society for Information Science, 30*(5), p. 282.

Research questions

The mixed method study targeted education graduate students, an underserved population in library information seeking research (Earp, 2008, p.74). Quantitative measures tracked participants' accesses to the tutorial components, number of revised searches and records examined, as well as the time spent in the tutorial, devising search strategies and reviewing results. Scores comparing students' initial (pre-tutorial) search

with their post-tutorial search were also used. The study's qualitative component centered on a think aloud protocol that also captured participants' mouse movements during problem solving in Ebsco databases. The study focused on four research questions including:

1. What search techniques did participants demonstrate in their initial search? This question considers what strategies and skills participants utilized in their pre-tutorial search such as selecting additional databases, employing Boolean operators, truncating terms, accessing the advanced search mode, conducting subject searches, and locating terms from relevant articles.
2. What general attributes were common among participants in their use of the tutorial? This question tracks the number of seconds individuals spent in the tutorial and the number of accesses to the various components of the tutorial. It explores how participants used the tutorial. Did participants refer back to the tutorial during their searches or merely utilize it as a one shot learning tool? How many tactics did participants read and did they access a variety of tactics or stay in one category? Were some tactics used more often than others? How much time did participants spend accessing the various tactics in the tutorial? How frequently did participants access the tutorial?
3. What search techniques did participants demonstrate in their final searches? This question compares the search techniques participants demonstrated in their revised searches after exposure to the tutorial. These techniques were not revealed in participants' initial search.

4. How did the tutorial affect the outcome of the problem solving activity? This question compared participants' initial search skills with those demonstrated in subsequent searches. It also compares participants' initial search scores with their final search scores for relevance, ability to answer the question, authoritativeness, and the quality of the response. In addition, it considers the number of revised searches participants conducted, the number of records they examined, and the time they spent devising search strategies and reviewing results. Were there relationships among the time spent in the tutorial, the number of tutorial accesses, the number of revised searches, and the time spent devising search strategies and reviewing results. In addition, how did the amount of time spent in the tutorial and the number of accesses to the tutorial, and the number of revised searches affect participants' final search scores. The question also examines participants' satisfaction level with the results. Lastly, the question noted any issues that affected participants' problem solving activities.

Outcomes facilitated the design of a protocol to guide students in applying relevant metacognitive strategies during online search thereby enhancing individuals' information seeking behaviors. These are discussed in Chapter five.

Limitations. The small number of students in the sample, eight participants, was a major limitation of the study and prevented the generalization of the findings. The study also attracted participants with more search experience than others. Similarly, some students were more knowledgeable in the task subject area or had enhanced database skills compared to others. Moreover, all of the participants stemmed from one academic institution's College of Education and had similar library training classes.

Summary

To improve education graduate students' information search behavior during problem solving exercises, this paper presents a mixed method study that evaluated the effectiveness of a tutorial designed to enhance participants' metacognitive strategies during information seeking for problem solving. The use of the think aloud protocol facilitated an understanding of individuals' strategies and perceptions as they searched for information to solve a problem. A variety of quantitative data offered evidence of the impact of the tutorial on students' problem solving abilities. The study focused on individuals' use of specific idea tactics and especially the differences in their problem solving efforts executed before and after exposure to the tutorial. The final chapter includes recommendations regarding the refinement and utilization of the idea tactics tutorial as a metacognitive intervention to enhance students' information seeking skills in digital libraries.

II. LITERATURE REVIEW

The literature review examined current literature in the field on information processing, metacognition, information seeking, information behavior, metacognitive scaffolds, and the think aloud protocol. First, material on information processing theory was offered as a theoretical framework for the study. Second, metacognition research was traced to illustrate the impact of cognition monitoring, self-regulation, comprehension monitoring, and problem solving abilities in affecting individuals' online search efforts. Third, studies on education graduate students' information seeking while problem solving in open ended environments were explored to highlight the difficulties students encounter in this process and to validate the significance of metacognition in improving their search outcomes. Fourth, research depicting users' information behaviors are reviewed to enhance understanding of the myriad of issues affecting the search process as well as the role of metacognition in online searching. Fifth, the significance of metacognitive instruction was explored to evidence the importance of metacognitive interventions in improving students' problem solving in computerized learning environments. Sixth, articles on tutorials, instructional design, the think aloud protocol, usability studies, and Camtasia are described.

Information processing theory

Information processing theory informed the theoretical framework for the study of education graduate students' metacognitive abilities and information seeking behavior. Information processing theory is based on Miller's (1956, 1960) concepts of chunk and

TOTE. According to Miller, individuals' abilities to chunk information, or recode it into units, allowed them to increase the amount of material they could successfully remember. His research on recoding coupled with Newell, Shaw, and Simon's (1962) work with information processing languages altered Miller's beliefs about what "guides behavior" (p. 2). In his publication *Plans and the structure of behavior* he likened man to a computer that contained plans, strategies, executions, and images. Miller described plans as hierarchies of instructions that identified the order of operations. On the other hand he defined images as "organized knowledge the organism has about itself and its world" and he believed that included "values" as well as facts (p. 17). According to the author, the feedback loop or Test-Operate-Test-Exit (TOTE) represented the basic unit of analysis for behavior (see Figure 1). He suggested individuals' actions resulted from a system of TOTE hierarchical units that were controlled by plans or processes. Although he acknowledged plans were inherited, he suggested variations in their source, span, detail, flexibility, speed, coordination, retrieval, openness as well as stop-orders fostered different behaviors among individuals.

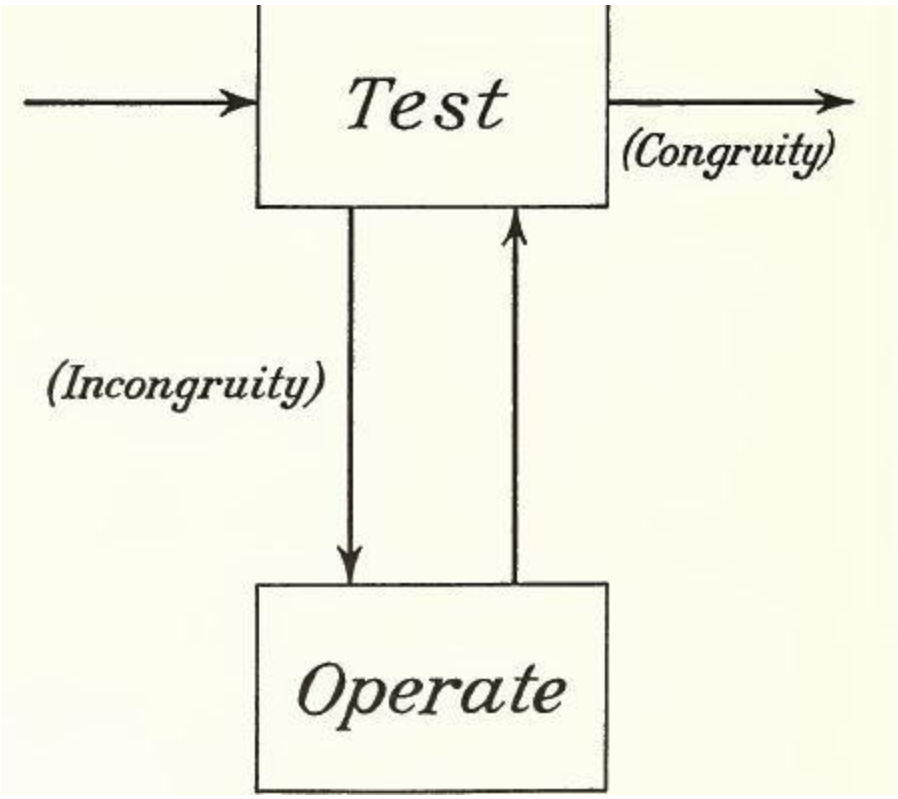

Figure 1. Miller's (1960) The TOTE unit of analysis for behavior. Adapted from *Plans and the Structure of Behavior*, by G. A. Miller, E. Galanter, and K. H. Pribram, p. 26, Copyright 1960 by Holt, Rinehart and Winston, Inc.

According to Miller individuals' problem solving was cyclical process that centered on information collection and included revision in images, predictions and testing. He argued individuals solve problems by utilizing images rather than systematic plans because these were inefficient. Miller suggested as individuals compared "what is" to "what ought to be" (1960, p. 174), they created images that served as potential solutions to problems. He believed individual's images were based on values and facts. Moreover, Miller attributed obstacles in the problem solving process to the inability of the image to represent the "problem situation" (1960, p. 174). On the other hand, he maintained that the formation of heuristic plans fostered the development of solutions to well-defined problems.

Human processing theory points to a general plan for human behavior, and acknowledges similarities among individuals' information processing skills. Foremost, the theory illustrates that the iterative nature of problem solving is reflected in the process of information collection, revision, and testing of the alternative images. This vision of problem solving suggests it is controlled by cognitive as well as metacognitive strategies as individuals continually regulate the process to develop new solutions. The theory also recognizes differences among individuals' metacognitive skills. Lastly, the theory highlights the role of the problem or information need in controlling the process. In this instance, a well-defined problem can be solved by a different approach compared to its ill-structured counterpart. According to Miller well-defined problems enable the searcher to "recognize the solution" while more complex problems do not have an easily identifiable way of revealing "what he is looking for" (p. 170).

Metacognition

Theorists differ on an exact definition of metacognition. Flavell (1981) defined metacognition as knowledge or cognition that "regulates any aspect of any cognitive endeavor" (p. 37). Brown and Palinscar (1982) identified two categories of metacognition knowledge about cognition and regulation of cognition. They described the latter as executive control processes that centered on planning, monitoring, and checking. Wellman (1983) noted that metamemory was a component of metacognition and he believed it was an "ill-defined concept" with "fuzzy" definitions (p. 33). He identified four common types of metacognition including: "factual long term knowledge about cognitive tasks, knowledge of one's current memory states, regulation of cognitive processes, and "conscious cognitive feelings" regarding the cognitive activity (p. 34).

Wolfe, Brush, and Saye (2003) summarized metacognition as "knowledge of self, the task at hand, and the strategies to be employed" (p. 322).

Beginnings of a concept. Flavell's research on children's memory development in the late 1960's illustrated the importance of metacognition in influencing behavior. He termed memory development "metamemory" and characterized it as the "intelligent structuring and storage of input, of intelligent search and retrieval operations, and of intelligent monitoring and knowledge of these storage a retrieval operations" (1971, p. 277).

Flavell's research with Wellman resulted in further refinement of the metacognition concept including the development of a metamemory taxonomy. This taxonomy recognized the need for "planful memory-related exertions" for some situations (p. 5). In addition, the taxonomy noted individuals' performance in these situations remained dependent on the memory characteristics of the person and the task, as well as the individual's available strategies. The taxonomy also identified sensitivity as well as the interaction of task, person, and strategy variables as two types of memory metacognition. The authors defined sensitivity as a situation that triggered individuals' voluntary intentional remembering. According to the article, individuals learned to differentiate the need for immediate information retrieval or for preparation for "effective future retrieval" (1977b, p. 6). Lastly, they outlined various activities, including elicited and spontaneous, that triggered an individual's efforts to retrieval information for immediate or later use.

Flavell (1979) elaborated on the metacognitive knowledge and metacognitive experience components of the taxonomy. He described metacognitive knowledge as

"beliefs about what factors or variables affect the course and outcome of cognitive enterprises" (p. 907). Moreover, he attributed metacognitive knowledge to prompting individuals to "select, evaluate, revise, and abandon cognitive tasks (1979, p. 908) and metacognitive experiences to fostering new goals and revising and abandoning others. He attributed metacognitive experiences to thoughts or feelings that occurred during an "intellectual enterprise" (1979, p. 906). He suggested metacognitive experiences often become metacognitive knowledge that has "entered consciousness." According to Flavell metacognitive knowledge and metacognitive experiences are "partially overlapping sets" since some experiences contain knowledge and some do not (p. 908). Those metacognitive experiences that lack knowledge will not become a component of our consciousness.

Flavell suggested as children develop they gain skill in assessing their capabilities as well as monitoring and interpreting "their immediate memory experiences" (1978, p. 218). In addition, he linked children's memory development to an increased understanding of factors that influence their memory retrieval efforts. Lastly, he maintained individuals' abilities to articulate and develop memory retrieval strategies improved with age.

Cognition monitoring. In 1981, Flavell introduced a model of cognitive monitoring that illustrated the interrelationship among metacognitive experiences, metacognitive knowledge, cognitive goals and actions. According to the author, individuals develop metacognitive strategies to monitor cognitive actions as well as metacognitive experiences to achieve goals. He advocated incorporating the cognitive monitoring model in teaching children oral communication skills through role reversals

between speakers and listeners. In this capacity Flavell believed, children learned "the phenomenological chasm between the mind that already knows and the mind that does not yet know" (p. 57).

Self-regulation. Throughout the late 1970s and 1980s, research on metacognition focused on understanding the relationship between metacognitive skills and elementary students' classroom performance. Brown and her colleagues (Brown, 1977, Brown & Palinscar, 1982; Reeve & Brown, 1984) explored self-regulation and particularly children's ability to control and regulate their mental processes. According to Brown and Palinscar (1982), metacognition contained two facets, knowing about cognition and regulating cognition. They likened the latter to executive control processes in information processing systems that included planning and monitoring activities as well as checking outcomes. Reeve and Brown (1984) identified some self-regulation metacognitive skills as summarizing, questioning, clarifying, and predicting (pp. 13, 15). To enhance children's self-regulation abilities, the authors promoted an interactive metacognitive intervention and they described several successful reciprocal teaching efforts that focused on improving students' metacognitive processes to improve students' text comprehension and reading skills.

Comprehension monitoring. Wagoner (1983) noted a hierarchical relationship among metacognition, cognitive monitoring, and comprehension monitoring. Markman (1977) defined the latter as constructive processing and in studies with elementary school children she demonstrated the inability of younger children to execute instructions mentally or to determine the relationship between instructions and the goal (1977, p.

991). She emphasized the importance of individuals' awareness of their lack of understanding in order to remedy the situation.

Markman (1981) pointed to inferential processing as a component of comprehension modeling. In this instance, individuals paraphrased information, drew implications, and identified examples to gauge their understanding of the material. In addition, she highlighted the metacognitive knowledge involved in the process noting individuals evaluated "material and task demands" and made "judgments about potential explanations" (p. 75). Ultimately she maintained comprehension monitoring remained a conscious process that centered on an individual's recognition of his failure to understand. This remained similar to Brown's (1977) definition of metacomprehension that she described as "ascertaining the state of one's own ignorance or enlightenment" (p. 9).

Problem solving and metacognition. Flavell (1976) linked metacognition to facilitating problem solving. According to the author, problem solving required metacognitive skills that he identified as "monitoring, and consequent regulation, and the orchestration of the processes in relation to the cognitive objects or data to achieve a goal" (p 232). He promoted instructing children in problem solving skills that included examining "task features carefully," searching both internal and external sources for "solution-relevant information and procedures", as well as tracking "past solution efforts, and outcomes" (p. 234).

Brown (1977, 1982) also recognized the benefits of metacognitive skills for problem solving. She identified these skills as "predicting, checking, monitoring, reality testing and coordination and control of deliberate attempts to learn or solve problems" (p.

1). Reeve and Brown (1984) argued children's abilities to gain control of and regulate their metacognitive processes enhanced their problem solving skills. Brown's (1977, 1982) work acknowledged the importance of self-awareness in efficient problem solving including knowing limitations, routines, identification and characterization of the problem, planning and scheduling of problem solving strategies, monitoring effectiveness of routines, as well as evaluating operations. Brown's findings agreed with Flavell in promoting metacognitive skill training in "checking, planning, asking questions, self-testing, and monitoring" to enhance individuals' problem solving efforts (p. 73).

Problem solving research highlighted the importance of memory to support the problem solving process. Newell and Simon (1972) identified the total knowledge available to the problem solver as a major component of the problem space, or the area where the problem solving activities occur. This consisted of temporary dynamic information, the knowledge state itself, access information, path information, access information to other knowledge states and reference information. According to the authors, the latter two information types were stored in an individual's long term or external memory.

In addition to the role of memory in problem solving, research highlighted the importance of individual's creation of a model to facilitate the process. Resnick and Glaser's (1976) discussed a model of problem solving that encompassed a three step process including problem detection, feature scanning, and goal analysis and also centered on an individual's memory. In this instance, problem solvers built a representation of the problem similar to Miller's (1960) image, searched their long term memory for past routines and redefined or revised the problem as needed. Pretz, Naples,

and Sternberg maintained mental representations are critical to problem solving and they identified four components of a model including: "a description of the problem," a description of the resolution or goal, a list of the operators, and an idea of the constraints (p. 6).

Information problem solving and metacognitive skills. Moore's (1995) work represented one of the earliest studies of users' application of metacognitive strategies while problem solving. The author examined sixth grade students' cognitive and metacognitive strategies as they utilized the school's library materials for an assignment. The author coded data gathered from interviews into three categories including: metacognitive knowledge, executive control processes, and cognition associated with information retrieval and use. Her findings suggested students lacked variety in their information seeking strategies particularly in defining their "information needs" (p. 23). Still, she emphasized all students "engaged in higher order activities associated with executive control processes" (p. 27). In the article's conclusion, the author highlighted the various factors affecting students' cognitive and metacognitive abilities such as students' knowledge of the library and its resources, the processes associated with information retrieval, and teacher expectations for the project.

Walraven, Brand-Gruwel, and Boshuizen (2009) examined secondary education students' problem solving competencies to determine their criteria for evaluating search results, sources, and information available on the Internet. The research question considered how students solve information problems and what criteria they used to evaluate sources. The scoring system revolved around three categories including constituent skills and their sub skills, as well as regulation activities. The results

highlighted students' lack of attention to evaluating sources and information. The authors surmised that students focused on searching and scanning activities rather than processing the information and organizing the final product.

Summary of information problem solving and metacognitive skills. Research on metacognition illustrates individuals' capacities to control their mental processes through cognition monitoring and especially self-regulation. Research also supports the role of metacognition for monitoring, regulating, and orchestrating the processes to foster the resolution of the problem. Furthermore, studies of the application of users' metacognitive skills while problem solving reveals variation among individuals in the use of metacognitive strategies especially between experts and novices. The literature underscores the value of enhancing individuals' metacognitive strategies while information seeking for monitoring, steering, and processing the material.

Education students' information seeking to support problem solving

Studies tracing education graduate students' abilities to locate online information to solve problems reveal numerous deficiencies in participants' abilities and underscore the need for instructing individuals in metacognitive techniques to enhance their search skills. These articles focused on problem solving through open ended learning environments (OELE) or technologies that contain "tools for manipulation and experimentation" to "promote discovery and evolution of personal beliefs" (Papert, 1993 as cited in Land & Hannafin, 1997, p. 47). In these studies, the OELE centered on the web since its ill-structured nature provided participants diverse opportunities for critical thinking, resource discovery, and scaffolding to support problem solving. Numerous authors view information seeking as a form of problem solving (Brand-Gruwel, Wopereis, & Vermetten, 2005;Laxman, 2010). As Land and Greene (2000) remind us

information seeking requires the abilities to identify the information problem, locate relevant materials, as well as synthesize and integrate information from a variety of sources. Ultimately, this research underscores participants' deficiencies in both metacognitive and information seeking behaviors. It also suggests education graduate students would enhance their web and database searching from planning, monitoring, and self-regulating their behaviors.

Problem solving as information seeking. Hill and Hannafin's (1997) study of education students' problem solving highlighted the importance of metacognitive knowledge and especially prior subject knowledge on participants' search strategies. The authors traced the effects of prospective and current teachers' metacognitive, system, and subject knowledge as well as their perceived orientation and self-efficiency on participants' world wide web search strategies. The data consisted of pre-surveys, post surveys, think aloud protocols, audit trails and post search interviews. The findings highlighted the importance of metacognitive knowledge and especially prior subject knowledge on participants' search strategies. On the other hand, the article chronicled the impact of participants' feelings of disorientation in severely hindering their search strategies. The authors surmised these feelings affected participants' abilities to "reference" their prior knowledge as well as their metacognitive knowledge (p. 58). In discussing the findings, the authors rated system knowledge, skill and experience with an information system, more critical than prior subject knowledge, knowledge and experience in a specific subject domain, in fostering search success. In the article's recommendation's section, the authors underscored the need for learners to assimilate new knowledge into "existing schemata" (p. 61) as well as view information from various

perspectives. The authors concluded learners required instruction in strategies for locating information in open ended systems.

Tabatabai and Luconi (1998) also studied education graduate students and linked metacognitive skills to improved search outcomes. The authors compared three experts and three novices' web-based problem solving strategies rating participants' skill levels according to the average amount of time they spent searching the web each week. Participants' cognitive task analysis and verbal protocols revealed experts devoted more time to planning search strategies, setting goals, and reflecting on the task compared to the novices. Experts also accessed a higher number of search engines and employed more navigational strategies than their counterparts in the study. The authors maintained the findings pointed to the value of instructing students in developing critical thinking skills, using metaphorical knowledge to map problems, and developing planning and self-regulating strategies to facilitate web searching.

In addition, Land and Greene's (2000) work with pre-service teachers' information seeking on the web highlighted the role of metacognition in problem solving. The authors observed nine pre-service teachers' information seeking processes to identify opportunities for instructional scaffolding for metacognitive processing. Participants worked in groups to locate resources and synthesize the material into a final product. Data from each group constituted the case and consisted of think aloud protocols, videotape observations, self- reports of system knowledge, and an examination of participants' final project. Three research questions guided the study including: identifying participants' strategies, determining the roles of system, domain, and metacognitive knowledge in their ability to locate resources, and illustrating users' skills

in integrating resources into the final project. The article attributed differences in case outcomes to participants' domain, system, and metacognitive knowledge. The authors suggested all groups illustrated evidence of metacognitive knowledge by reflecting and monitoring the search process. However, the authors linked "effective metacognition" to system and domain knowledge (p. 57). In addition, the findings revealed groups that established goals initially and subsequently located resources were more likely to develop a final project. Similarly, the researchers attributed difficulties with participants' search strategies to failing to revise ineffective search terms, not identifying the search goals, and focusing on data driven strategies. Consequently, the article recommended assisting learners to "reflect on and articulate their ongoing understanding in a complex learning environment" (p. 64).

Likewise, Tabatabai and Shore's (2005) research underscored the role of metacognitive skills in enhancing participants' information seeking for problem solving. The authors explored variation among search habits for 10 undergraduate pre-service teachers (novices), nine library and information studies graduate students (intermediaries), and 10 professional librarians (experts) utilizing a think aloud protocol. The authors defined information seeking on the web as an "ill-defined problem solving task" due to the complex nature of the system (p. 224). They sought to understand if experts utilized different strategies than intermediaries and novices as well as the relationship between strategies and the timely success of web search. The data categorized participants' strategies according to six events: evaluation, navigation, affect, metacognitive, cognitive, and prior knowledge. The findings revealed that experts monitored themselves and the process more than other participants. Experts also devoted

an increased amount of time to cognitive strategies such as thinking, reading and planning compared to intermediaries and novices. On the other hand, the latter participants were more likely to become frustrated with the process. The authors pointed to novices' tendency to lose patience and rely on "trial and error" (p. 238). The study identified evaluation and metacognition as the two most important strategies in facilitating searching success. In their conclusion, the authors highlighted the importance of instruction for student teachers in web searching such as understanding "criteria for evaluating sites", "thinking and planning" search strategies, reflecting and monitoring the search process, and maintaining a positive attitude during the process (p. 240).

Foremost the literature illustrates the need for providing education graduates students' metacognitive support in problem solving due to their difficulties in information seeking in open ended environments. For example, the literature emphasized the importance of the Internet and especially online resources to these students, but it also noted students remained confused about selecting sources (Earp, 2008; Green & Mccauley,2007; Park,1986). Moreover, Blummer. Lohnes, and Kenton (2009) reported students appeared dissatisfied with their previous library instruction. In addition, numerous authors emphasized the importance of flexible instruction and providing "new skills, new knowledge" (Green & Macauley, 2007, pp. 328-329).

Summary of research on education students' information seeking to support problem solving. An examination of the literature on education students' problem solving abilities, especially from an information seeking perspective, highlights the various deficits that exist in this population. Foremost, these individuals lack metacognitive skills in planning, monitoring and self-regulating their information search

behavior. Hill and Hannafin's (1997) study illustrated the role of participants' metacognitive knowledge in facilitating users' abilities to refine their search tactics thereby maximizing the information potential of the web. Likewise, Land and Green's (2000) research revealed that metacognitive knowledge compensated for low subject and domain knowledge and they believed this was particularly important in information seeking in open ended environments. As the literature indicated information seeking to support problem solving represents a complicated process that requires metacognitive abilities, search skills, domain knowledge, and recently familiarity with computer systems. Individual deficiencies in these areas foster numerous consequences that affect individuals' problem solving producing user frustration, ineffective search techniques, lengthy search processes, and unsatisfactory search results.

Metacognitive skills and users' online search behavior

Traditional library training focused on bibliographic instruction and users' information literacy skills. Prior to the development of the world wide web, librarians provided bibliographic instruction to students in using indexes and catalogs to locate material for research topics. Students were also given information about relevant sources in their field such as journals, books, and reviews. In addition, some library training included instruction on methods for conducting a literature review.

In the late 1980s library training highlighted individuals' information literacy skills. In addition to instruction in using indexes and other sources, librarians promoted Boolean search techniques, utilizing web and database features in searching as well as evaluating websites. Foremost, these training efforts supported the Association of College & Research Libraries' Information Literacy Competency Standards for Higher Education.

These standards promoted students' abilities to recognize an information need, access the information, evaluate the information, use information effectively, as well as understand the ethical and legal implications of its use.

However, the literature on information behavior, information seeking and information retrieval also support the use of a metacognitive intervention to assist education graduate students information problem solving. This research identifies various deficiencies in the user as well as the process that impede individuals' information seeking activities especially in digital libraries. The studies also highlight the potential of metacognitive techniques for improving users' search behaviors and outcomes.

Information studies. Information studies research highlight difficulties that impede the search process. Taylor (1962) pointed to three obstacles that affected individual interaction with an information system such as the system organization, the question type and complexity, and "the state of readiness" (p. 394). Dervin (2004) characterized the process as sense-making since she maintained individuals sought to locate information and resolve the gaps or discontinuities that existed between entities, times, and spaces. Kuhlthau (1993, 2004) joined Ellis (1989) in recognizing distinct stages in individuals' information seeking that she identified as initiation, selection, exploration, formulation, collection, and presentation. She argued an uncertainty principle paralleled the user's migration through these stages. Moreover, Saracevic (1997) pointed to the volatile nature of information retrieval due to the user's ill-defined problem that led to revisions in queries which impacted other levels. Wilson (1999) promoted a problem-solving model for information behavior that incorporated elements from other models (see Figure 4). In this model Wilson demonstrated how users'

uncertainties, as noted by Kuhlthau, stemmed from the problem situation and he that argued its resolution occurred in stages that may include a feedback loop. His model highlighted the problem solving focus of information seeking that may require several search attempts prior to locating information to solve the problem.

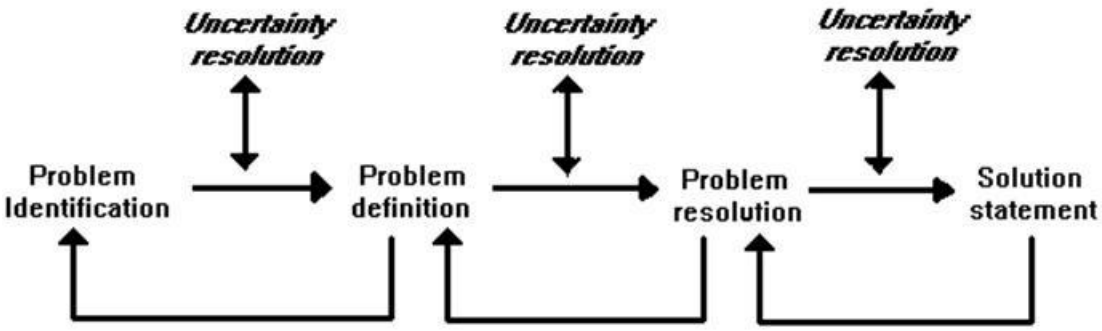

Figure 2. Wilson's (1999) problem solving model. This depiction underscored the role of the problem in information seeking. Adapted from "Models in Information Behavior Research," by T.D. Wilson. Retrieved March 5, 2010, from http://informationr.net/tdw/publ/papers/1999JDoc.html

Metacognitive techniques in online search. Information studies highlight the importance of cognitive as well as metacognitive techniques in online search. Storrs (1993) noted the need to understand participants' capacities for information and particularly their "computational or cognitive" processing abilities (p. 178). References to evaluation, reflection, absorption, attention, and interpretation in the literature's information seeking models suggest users' exercised metacognitive strategies and these assumed an integral role in their information seeking. Marchionini (1995) attributed metacognition to driving our information needs enabling "our general information seeking knowledge" (p. 14). Research by Pharo (2004) alluded to the role of

metacognition in information search too. His Search Situation and Transition model centered on work tasks and offered a comprehensive view of the various forces affecting information seeking. The model noted the importance of the searcher's "attention" that the author defined as the "ability to notice useful information as it appears during the search process" (para. 16).

Research in other disciplines also recognized the role of metacognition in online search. Quintana, Zhang, and Krajcik (2005) highlighted the "multifaceted" nature of online searching that required users' metacognition skills (p. 235). They described metacognitive knowledge as knowledge about individual learning capacities, the task at hand, and strategies. On the other hand, they defined metacognitive regulation as "regulating one's own cognition" (p. 236). According to the authors, both kinds of metacognition were required for searching since they provided "executive control" of the process (p. 236). Lazonder and Rouet (2008) equated metacognitive skills in online search to planning the search, monitoring its progress, and evaluating results for "relevance, reliability, and authority" (p. 759).

Likewise, Navarro-Prieto, Scaife, and Rogers' (1999) study of web searchers revealed more experienced searchers developed a plan for finding the information and also remained flexible in their use of strategies. Their research also revealed that novice searchers began with very broad questions and narrowed their search terms with "words suggested by the search engines" (para. 23). According to the authors, the study's results fostered the expansion of their model of web searching behavior from the user, the task, and external representations to include individuals' cognitive strategies. The authors

suggested these strategies evolved from users' past search experiences as well as the structure of the information presented.

Narciss, Proske and Koerndle (2007) maintained that individuals' self-regulation remained especially important for learning in hypermedia environments due to their "extensive amounts of information, non-linear structure and technological inconsistencies and limitations" (p. 1128). They pointed to research by Azevedo (2002), Chen and Rada (1996) as well as Dillon and Gabbard (1998) that indicated students lacked control over their learning in these environments due to their inabilities to exercise self-regulating activities.

Bannert (2006) also cited research that noted students got "lost in hyperspace" and experienced feelings of disorientation in these environments (p. 360). She attributed these experiences, in part, to students' failure to perform metacognitive activities to promote web-based learning. She noted the need for learners to "analyze the situation," orient themselves to the task, identify learning goals, plan procedures, instigate searches, judge relevance, and evaluate learning (p. 360).

Summary of research on metacognition in online search. The discussion of information behavior and retrieval research underscores the need to improve users' metacognitive strategies during search in digital libraries to enhance retrieval outcomes. Theorists pointed to individuals' feelings of uncertainty and confusion as they confront an information need. Educational technologists also maintain students lack strategies to interact successfully in hypermedia environments. Yet librarians' efforts to combat these feelings through traditional information literacy instruction have often failed. This could stem from their focus on what Lupton and Bruce (2010) describe as generic information.

As Diekema, Holliday and Leary (2011) note this instruction provides tips on how to search databases, but not how to "process, analyze, and apply" the information. Individuals still demonstrate ineffective search practices, note feelings of anxiety, and also complain of an inability to locate relevant materials while searching digital libraries (Blummer, Lohnes, & Kenton, 2009; Hartson, Shivakumar, & Perez-Quinones, 2004). Research linking metacognitive interventions to facilitating learning in hypermedia environments suggests education graduate students may benefit from a tutorial designed to enhance their online search efforts during problem solving.

Promoting metacognition

Metacognition training, by focusing on strategies to enhance an individual's mental processing, such as in planning, monitoring and self-regulation, offers enormous potential for supporting individuals' information seeking in digital libraries. Hill and Hannafin (1997) remind us weak metacognitive knowledge and skill affected the abilities of web searchers to define learning needs, evaluate resources, and revise learning strategies. The idea tactics included in the tutorial stem from metacognitive strategies employed by professional information searchers to enhance their search results. These techniques should improve the outcomes of education graduate students' information seeking while using digital libraries.

Metacognition & instruction. While the foundation of metacognition studies discussed above centered on improving children's academic success, researchers also noted the potential for instructing adults in techniques to improve their metacognition. Brown and Palinscar (1982) linked intelligence to planning and executive control functions and noted the tendency for humans as well as computer programs to remain

deficient in these areas. Flavell (1979) maintained there was “too little” cognitive monitoring for adults as well as children. He also suggested a role for cognitive monitoring in teaching children and adults how to “make wise and thoughtful life decisions as well as “comprehend and learn better in formal education” (1979, p. 910).

Osman and Hannafin (1992) discussed incorporating metacognitive strategies into instructional design. They identified four design types based on the training approach and the strategies’ relationship to the lesson content (Table 2). The authors warned against developing strategies that “compete for task-essential cognitive resources” (p. 94). In addition, they promoted the utilization of higher-order strategies for adults and individuals with substantial subject knowledge for instructional design.

Metacognitive interventions. Research on metacognitive interventions suggests that these tools improve college students’ online inquiry and especially problem solving. Bannert (2006) described interventions as metacognitive support devices designed to “increase students learning competence” through “system instruction” (p. 361). Lin and Lehman likened them to scaffolds that “support learning where students cannot proceed alone” (p. 840). Ultimately as Wolf, Brush, and Saye (2003) maintained, teachers and designers can assist learners in building strong metacognitive skills through the use of interventions.

Table 2

Osman and Hannafin's (1992) Metacognitive Instructional Design Types

Type of Strategy	Design Features	Examples
Embedded content dependent strategies	Manipulation of the content, text structure, content dependent, focuses on internal Lesson organization	Embedded mastery study questions, chapter summaries, overview of given lesson, orienting activities
Embedded content independent strategies	Implicit content manipulation, rationale for strategy use, embedded prompts for using a strategy	Self-monitoring checklist, comprehension assessment techniques, generative summaries and questions
Detached content dependent strategies	Determining major learning tasks, selecting research based reasoning and thinking strategies, providing examples and feedback	Note taking, highlighting, underling key points, active listening and participating
Detached content independent strategies	Selecting research based reasoning and thinking strategies, designing and developing independent learning skills	Summarizing strategies, paraphrasing, imagery, analyzing ideas

Note. Adapted from **"**Metacognition research and theory: Analysis and Implications for Instructional Design," By M. E. Osman and M. J. Hannafin, 1992, *Educational Technology Research & Development*, *40*, pp. 91-92

Many of the interventions discussed below focused on the provisions of prompts or questions to participants aimed at fostering their self-regulating behavior for problem solving. Azevedo (2005) defined self-regulation as individuals' efforts at planning, monitoring, regulating, and controlling their "cognition, motivation and context" (p. 201). Chen and Ge (2006) suggested prompts encouraged individuals to engage in self-questioning, monitoring, and reflecting activities. The authors also maintained that system generated questions facilitate problem solving by guiding students in representing and solving problems.

Lin and Lehman (1999) demonstrated the significance of prompts in assisting undergraduate education students to self-regulate their learning for problem solving during computer simulated laboratory experiments. The study's participants received various types of prompts including: reason justification (students provided the reasons for their actions), rule based (students explained the rules and conditions), and emotion focused (students described their feelings). There was also a control group that did not receive prompts. The results revealed students that received the reason justification prompt performed better than the other groups in the post-test for solving far transfer problems. The authors described these as problems that were "contextually dissimilar" and "more complex" (p. 897). Bannert's (2006) findings confirmed these results. In this instance, 24 undergraduate psychology and education majors utilized reflection prompts to navigate a hypermedia system. Those individuals receiving the intervention illustrated better far transfer performance than the control group. She joined Lin and Lehman in maintaining solving these types of tasks required a deeper understanding that the participants gained from efforts to support their metacognitive activities during their interaction with the hypermedia system.

Wolf, Brush, and Saye (2003) embedded metacognitive scaffolds into a database to illustrate the effects of providing support to students' information problem solving. These metacognitive scaffolds centered on the Eisenberg and Berkowitz Information Problem Solving Model (EBIPS). In this study seventeen eighth grade students utilized the scaffolds to complete an assignment while an equal number of participants conducted research without extensive EBIPS support. These individuals primarily utilized the features available in the messages component of the database, since access to the

scaffolds remained optional for these students. The findings supported the role of metacognitive scaffolds in enhancing students' research skills. According to the authors, the products created by students with access to the EBIPS model were more accurate, contained a greater variety of resources, and reflected an increased attention to detail than those assignments completed by participants in the control group.

Huttenlock (2007) reported on the use of an advance organizer to enhance college students' metacognitive strategies and search results during an ill-structured problem solving activity. The advance organizer contained reflective questions designed to facilitate users' abilities to explain and think about their actions. In this study three participants searched databases utilizing the organizer and three completed the exercise without benefit of the tool. The findings noted participants that utilized the advance organizer employed "deliberate and focused" metacognitive questioning in their interactions with the instructional tool (p. 109) and also incorporated the questions into their individual search behaviors. In addition, they reflected more on their search outcomes and strategies compared to those participants that did not use the advance organizer. Huttenlock found that the advance organizer was used instead as a worksheet because it was not used consistently among the participants. She maintained the "key to its effectiveness" was its ability to foster questions and reflections during searching (p. 132).

Similarly, Kauffman, Ge, Xie, and Chen (2008) investigated the availability of automated instructional prompts in fostering individuals' problem solving in a web environment. Half of the study's participants, 54 undergraduate pre-service teachers, received self-reflection and problem solving prompts to enhance their abilities to scaffold

the process. The reflection prompts were designed to encourage students to consider "how well they solved the problem and to evaluate and revise solutions" (p. 119). The authors concluded that students that received the prompts, especially those focused on problem solving, remained more skilled at representing the problem, developing solutions, and constructing the argument than those that lacked the intervention. Kauffman (2008) et al. reported the importance of students' exposure to both types of prompts and the authors linked students' reflection to promoting a "clear understanding of their problem solving process (p. 133).

Stadler and Bromme (2007) also explored the role of metacognitive prompts in fostering web-based inquiry. They sought to illustrate web searchers' abilities to form representations of document contents and web sources utilizing metacognitive knowledge. To this end, the study centered on providing participants evaluative prompts, monitoring prompts, both prompt types and no prompts during a web search session. According to the results, individuals receiving evaluating prompts appeared more knowledgeable about the sources and demonstrated more abilities to justify the credibility of a source than their counterparts in the study. In addition, those participants that received the monitoring prompts had more knowledge about the facts. The authors concluded the study supported the role of metacognition in forming document models for managing multiple documents on the web.

Research suggests scaffolds can encompass guides, strategies, and tools that may be human or non-human devices (Azevedo, 2005; Azevedo, Cromley, & Seibert, 2004, p. 346). To this end, the review of metacognitive interventions' studies included research

tracking the impact of instruction, human scaffolds, as well as elaborate feedback systems on affecting students' problem solving activities.

Wopereis, Brand-Gruwel, and Vermetten (2008) embedded information problem solving instruction in a distance education course to increase students' abilities to solve web based information problems utilizing websites and news groups. The online training emphasized the use of metacognitive activities including monitoring, steering, and testing during students' problem solving. The authors concluded students in the experimental group that received the instruction "regulated" the information problem solving process more often than those in the control group and the researchers suggested this promoted "effectiveness and efficiency" in problem solving (p. 749).

Likewise, Saito and Miwa (2007) evaluated a feedback system that encouraged users to reflect on their problem solving process while seeking information on the web. The authors defined reflection as a "cognitive activity for monitoring, evaluating and modifying thinking and process" (p. 215). In this study 19 university freshmen conducted web searches to solve information tasks utilizing the feedback system. An equal number of students performed similar web searches without benefit of the intervention. Pre-test and post-test comparisons revealed participants in the experimental group utilized more keywords and visited more web sites with the availability of the feedback system.

In addition, Bannert, Hildebrand, and Mengelkamp (2009) investigated the effectiveness of a metacognitive support device to enhance learning among college students. Researchers instructed half of the participants, 57 university students, in the benefits of utilizing metacognitive techniques to promote learning. A control group received instruction in creating an ergonomic working space. Both groups were

encouraged to take notes during the learning session that focused on pictures in multimedia learning environments. The results revealed that students in the experiment group demonstrated a "higher amount of metacognitive activities" during the session as well as "better transfer performance" than the control group (p. 832).

Azevedo, Cromley, and Seibert (2004) considered the role of adaptive scaffolding in helping college students regulate their learning with hypermedia. The research focused on whether adaptive scaffolding, by monitoring students understanding and providing support when necessary, remained more effective in supporting students' self-regulated learning (p. 347). Study participants included 51 undergraduate students that received adaptive scaffolding, fixed scaffolding, and no scaffolding during their learning of the circulatory system from a CD-ROM encyclopedia. The authors noted students that received adaptive scaffolding engaged in more instances of planning, monitoring, and enactment of effective strategies compared to the control group. The article concluded participants exposed to the adaptive scaffolding gained a deeper conceptual understanding of the material compared to the other participants in the study (p. 361).

Summary of promoting metacognition. The research on metacognitive instruction and especially interventions illustrates the importance of efforts to support individuals' metacognitive skills to facilitate learning in hypermedia environments. Studies link scaffolds to promoting individuals' self-regulating, monitoring, and reflecting activities. These skills increase individuals' abilities to process information in hypermedia environments and they remain particularly critical in supporting problem solving.

Tutorials for library skills instruction

The importance of web tutorials as a form of user instruction in libraries remains undisputed. Silver and Nickel (2007) reported online tutorials remained as effective as in-person instruction for library training. The authors join other theorists in noting students' preferences for online rather than face to face library instruction due to the flexibility of this approach (Hoffman, et al., 2008). Foremost, these online learning tools offer flexibility for use within course instruction or as stand-alone modules. Viggiano (2004) suggested tutorials offer avenues to serve distant learners or the library's "hidden users." (p. 50).

Development. The incorporation of sound pedagogy in the development of tutorials promotes effective instruction. Gagne's principles of instruction represent a popular method of instructional design that can be utilized in online instructional tools. This technique, described in Table 3, focuses on activating an individual's mental processes to facilitate learning (Kruse, n.d.). Studies link the incorporation of instructional design principles to effective learning. Smith and Ragan (1993) listed the main components of instructional design as analysis, strategy, evaluation, and revision. They also underscored the need to analyze the learner, as well as the learning context and learning task.

Instructional design in online tutorials. The incorporation of instructional design principles such as the directive e-learning architecture and multimedia principles also enhances learning in online tutorials. Clark and Mayer (2008) promoted a directive e-learning architecture that contained explanations and examples. The authors described

Table 3

Gagne's Nine Events of Instruction

Instructional Event	Technique
1.Gain attention	Participant brings their own search problems for the activity
2. Discuss objective	Enhance information seeking to improve satisfaction with search results
3. Stimulate recall of prior learning	Participant searches using their traditional method
4. Present content	Tutorial is offered that contains metacognitive idea tactics as prompts
5. Provide learning guidance	Participants are also given access to a print version. Researcher addresses any questions or comments
6. Practice	Participants practice new skill
7. Provide feedback	Participants discuss search outcome with researcher
8. Assess performance	Participants note any problems with search
9. Enhance retention & transfer	Participants institute another search

Note. Adapted from "Gagne's Nine Events of Instruction: An Introduction," by K. Kruse, n.d. Retrieved September 17, 2010 from http://www.e-learningguru.com/articles/art3_3.htm

this type of information architecture as requiring a moderate level of interaction for users and especially useful for software skills instruction (p. 27). They also advocated adherence to numerous e-learning principles to promote active knowledge construction. For example, they promoted the multimedia principle that offered graphics as well as words to access dual channels for information processing. According to the authors, research suggested learners learn "more deeply from words and pictures than from words alone" (Clark & Mayer, 2008, p. 66). Meer (2000) also noted the importance of well-designed graphics to improve the "visual appeal" of the tutorial (p. 245). She pointed to

research by Murphy and Hubble that revealed users prefer “fewer words and more pictures” (p. 245).

Clark and Mayer (2008) also urged developers to incorporate the contiguity principle in instructional design. In this instance words are aligned to graphics to reinforce the presentation of the material. According to this principle, integrating text and pictures reduced learners’ cognitive load since it eliminates the need to match the graphic to the text. The contiguity principle also promoted consistency in information presentation to underscore its readability.

Two additional instructional design strategies include the utilization of a conversational tone and avoiding redundancy in information presentation. Studies suggest learners’ process information at a deeper cognitive level when personal emphasis is highlighted through the use of “you” and “I” in the narration (Clark & Mayer, 2008. p. 162). In addition, instructional design principles warn against redundancy of information presentation. In this instance the redundancy principle states the presentation of audio and text overloads the learner’s cognitive channels thereby interfering with their ability to process the material.

Likewise, instructional designers support the organization of the material in segments. Studies illustrate learners’ cognition of new material is facilitated when it is divided into “bite-size” segments (Clark & Mayer, 2008, p. 190). Moreover, another instructional design principle includes the coherence principle that aims to keep the lesson as uncluttered as possible (Clark & Mayer, 2008, p. 133). This principle advises designers against including any material that does not support the instructional goal.

Researchers suggest extraneous information interferes with the learning process by hindering the individual's ability to "make sense of the printed material" (p. 141).

Lastly optimal instructional design centers on interactivity. Meer (2007) highlighted the importance of a tutorials' interactivity to engage users. Clark and Mayer (2005) linked interactivity in online learning environments to far-transfer learning. In the online tactics tutorial, students can view screen captures of database search results that provide expert modeling. In addition, Dietz-Uhler (2003) discussed the incorporation of practice sessions in her tutorial that was designed to teach students how to evaluate web sites. According to the author, the novelty of the tutorial stemmed from its "active learning approach" where students applied the evaluation criteria to various sites (p. 12).

Think aloud protocol, usability studies, & Camtasia

Think aloud protocol methodology. Research on the think aloud protocol highlights its effectiveness in capturing users' cognitive processes during information problem solving. The technique's use in psychology dates to the late eighteenth century and numerous psychologists noted the credibility of the approach for predicting behavior (Miller, 1960). Ericsson and Simon (1984) said the protocol supported an interpretation of human cognition from an information processing perspective that stipulates "recently acquired" information is stored in the short term memory (p. 11). The authors described the method as a "powerful means for gaining information" about cognitive processes that control behavior (p. 30). Still, they emphasized the importance of providing proper instructional procedures for participants to enhance the validity of the responses.

Studies that tracked think aloud protocol and users' metacognition illustrates its value in promoting comprehension. Gazda (2005) utilized the think aloud protocol to

track metacognitive search behaviors of fourteen nursing students as they navigated through a hypermedia system. The author categorized their metacognition as organizing, monitoring and modifying their navigation. He observed the most efficient searchers had the least instances of disorientation, while the least efficient searchers experienced the highest number of these feelings. In his summary he noted the interrelationship among individuals' hypermedia search strategies, navigational efficiency, and metacognitive behavior in instructional hypermedia environments.

Thinking aloud helped students identify strategies to improve their understanding by activating prior knowledge, relating text to prior knowledge, inferring, and reflecting. Israel and Massey (2005) discussed the use of think aloud protocol to promote reading comprehension among middle school students The authors maintained the think aloud approach enables student to monitor their comprehension. Their research suggested thinking aloud helped students identify strategies to improve their understanding by activating prior knowledge, relating text to prior knowledge, inferring, and reflecting.

The think aloud methodology remains especially popular for evaluating websites and databases, but it should be used with other data collection methods. Hoppmann (2007) employed the think aloud protocol to examine users' "point of frustration" when searching the official website of the European Union. She listed several advantages to the think aloud approach. First, it can be employed in studies with a limited number of participants. Second, the strategy involves minimal cognitive processes because the protocol stems from the individual's working memory. Third, the technique remains appropriate for quantitative and qualitative studies. However, she noted as the demand on the users' cognitive process increases, thinking aloud may prove difficult for the

participant. To that end, she advocated incorporating the strategy in combination with other data collection methods. His website usability study included data from questionnaires, think-aloud protocols, and in-depth interviews. According to the author, the findings demonstrated the role of user attitudes towards computers and online information in affecting their satisfaction levels.

Usability study. A database usability study using the think aloud protocol reveals users feeling and thoughts during information search. Tenopir et al.'s (2008) usability study of the University of Tennessee's faculty, graduate and undergraduates' interaction with the Science Direct database also centered on the think aloud protocol in a task scenario. This study focused on the relationship between cognitive behavior and affective reactions and particularly what feelings and thoughts occurred during search. An analysis of the transcripts revealed positive, negative and neutral responses associated with participants' feelings. The authors linked individuals' cognitive activities to four categories including: the software system, the search results, the search strategy, and the task. The outcomes revealed users experienced more positive than negative feelings and all thoughts typically occurred during users' views of the search strategies and results. Moreover, participants were more likely to have negative feelings with thoughts concerning the system, search strategy and task.

Another usability study that focused on the think aloud protocol in evaluating a federated search product highlighted the importance of clarity in interfaces to enhance use. Likewise, George's (2008) usability study of software that allowed individuals to search multiple databases simultaneously focused on a mixed methods think aloud protocol. Participants were asked to complete six tasks that resembled "real-world" (p.

18) searches. Following the task activity, participants answered a questionnaire that rated their experiences based on a 5 point Likert scale. The study's findings fostered a list of recommendations aimed at improving the usability of the software. Some of these recommendations included: offering login information, enhancing navigation levels, improving clarity for names and icons, and maintaining consistency throughout the site.

Evaluation of a library website using the think aloud protocol enabled an understanding of how easily students could locate information on the site. Stephan, Cheng, and Young's (2007) usability survey of the University of Mississippi's Libraries' home page highlights the relevancy of these studies in supporting information seeking research. Participants tackled eight tasks involving simple and complex searches that required students access the library home page and the catalog as well as commercial databases. Some of these tasks required students locate a copy of the *Catcher and the Rye*, the course reserves page, an article in the Ebsco database, and the library's hours. Quantitative data collected included the number of clicks to reach a source, the time required to complete the task, if the task was completed, and participant's satisfaction level in completing the task. Observers also gathered participant's comments or any additional qualitative information that reflected user's feelings of indecision or frustration. Although the study did not meet the established benchmark of 75% completion rate on all tasks, the survey did foster the redesign of the website and led to the promotion of instructional techniques for interacting with the library's databases.

Camtasia. Camtasia supports the think aloud protocol by creating a video that captures individuals' mouse clicks, menu navigation, as well as comments to foster an in-depth analysis of the activity. The literature on screen capture software supports its use

with the think aloud protocol. Goodwin (2005) employed Camtasia as a tool to capture participants' screen movements and voice during a Texas A & M University's Libraries' website's usability study. She noted the software reduced errors associated with having a human recorder and also decreased the labor intensity of the project. According to the author, the software's capability to save the data into a file allowed for its subsequent review and manipulation. She described the software's learning curve as "flat" and the recording mechanism as "easy" (p. 620). The author linked the software to facilitating the library's effort to gather administrative support for a website redesign project. Corbus, Dent, and Ondrusek (2005) also utilized Camtasia in their evaluation of the Hunter College's Library's website. An analysis of the recordings from screen captures of participants' movements allowed the librarians to identify and correct problems with the site.

Summary of literature on instructional design, think aloud protocol, usability studies, & Camtasia. Research underscores the value of creating tutorials that adhere to instructional design principles. Moreover, articles on think aloud protocol point to its role in evaluating users interaction with databases as well as its ability to enhance individuals' metacognition. Foremost, the think aloud protocol allows researchers to track individuals' cognitive processes during problem solving. Finally, articles describing Camtasia support its use in research that employs think aloud protocol by providing a means of archiving the audio and video recordings to facilitate subsequent analysis.

Summary

Studies on education graduate students problem solving abilities identify their weakness in applying metacognitive skills to locate information. Articles on

metacognitive scaffolds demonstrate their effectiveness in enhancing users' planning, evaluating, and self-regulating skills during problem solving. Moreover, a sampling of research on tutorials, instructional design, and the think aloud protocol provides justification of their incorporation in the study. The literature on tutorials supports their effectiveness as a tool for library skills instruction. In addition, an examination of the principles of instructional design points to their role in enhancing online learning environments. Likewise, studies pertaining to the think aloud protocol reveal its value in tracking users' interaction with instructional devices especially their problem solving strategies and individuals' perceptions of the process. Articles discussing Camtasia evidence its usefulness in capturing participants' think aloud protocols as well as individuals' navigation, mouse movements, and mouse clicks during information search of digital libraries.

Finally, the literature on metacognition, human processing theory, and information problem solving revealed the varying theoretical perspectives on information use. Miller (1960) and Bates (1979) pointed to a behaviorist approach in analyzing human use of information. Flavell (1971, 1977, and 1979) and his followers promoted a cognitive perspective that included executive control processes and metacognitive knowledge. On the other hand, Dervin (1982, 1983) adopted a discursive view that portrayed the individual as constantly analyzing information to resolve inconsistencies in their environment that she termed sense-making.

In his essay "Psychology and Information," Miller (1968) discussed the importance of future information systems' abilities to simulate a "spatial frame of reference" (p. 289) to facilitate the user's ability to find information. Bates also

recognized the value of the user's perception of location in supporting information retrieval and she promoted more research into users' mental processes in locating information. According to Bates, "better understanding of these systems promoted "improved information organization and retrieval" (p. 286). Consequently the theoretical framework and methodological design of the current study support these perspectives in its effort to track users' strategies to facilitate information location and use.

III. METHODOLOGY

This mixed method research explores the impact of a metacognitive based intervention on education graduate students' information seeking habits in digital libraries. The study focused on participants' use of some of Bates' (1979) idea tactics provided in a tutorial while they located information for problem solving. It required participants think aloud as they searched library databases to locate information on their topic before and after exposure to the tutorial. The method yielded quantitative and qualitative data. A pre-search captured students' database search skills and problem solving strategies. This data was compared with the results of participants' information problem solving activities. The analysis also considered individuals' application of specific idea tactics and how these strategies affected the outcome of their information search during the problem solving activities. The chapter on data analysis presents a description of each participant's experiences with the tutorial individually. Additional information derived from the think aloud protocol coupled with post-search interviews reveals motivations for participants' actions, issues associated with the problem solving process, and individuals' satisfaction level with their search outcomes. This information will be presented for the group experience.

Specific research questions

1. What search techniques did participants demonstrate in their initial search? This question considers what strategies and skills participants utilized in their pre-tutorial search such as selecting additional databases, employing Boolean

operators, truncating terms, accessing the advanced search mode, conducting subject searches, and locating terms from relevant articles.

2. What general attributes were common among participants in their use of the tutorial? This question tracks the number of seconds individuals spent in the tutorial and the number of accesses to the various components of the tutorial. It explored how participants used the tutorial. Did participants refer back to the tutorial during their searches or merely utilize it as a one shot learning tool? How many tactics did participants read and did they access a variety of tactics or stay in one category? Were some tactics used more often than others? How much time did participants spend accessing the various tactics in the tutorial? How frequently did participants access the tutorial?
3. What search techniques did participants demonstrate in their final searches? This question compares the search techniques participants demonstrated in their revised searches after exposure to the tutorial. These techniques were not revealed in participants' initial search.
4. How did the tutorial effect outcome of the problem solving activity? This question compares participants' initial search skills with those demonstrated in subsequent searches. It also compares participants initial search scores with their final search scores for relevance, ability to answer the question, authoritativeness, and the quality of the response. In addition, it considers the number of revised searches participants conducted, the number of records they examined, and the time they spent devising search strategies and reviewing results. Were there relationships among the time spent in the tutorial, the number of tutorial accesses, the number

of revised searches, and the time spent devising search strategies and reviewing results. In addition, how did the amount of time spent in the tutorial and the number of accesses to the tutorial, and the number of revised searches affect participants' final search scores. The question also examines participants' satisfaction level with the results. Lastly, the question notes any issues that affected participants' problem solving activities. Table 4 lists the data type utilized to support the research question analysis.

Table 4

Data Type Utilized in Research Question Analysis

Research Question	Data Type
Research question 1	Audio file & screen capture
Research question 2	Audio file & screen capture
Research question 3	Audio file & screen capture
Research question 4	Audio file, search score ratings, & Post activity interview

Research design

Problem solving activity. The study's mixed design aimed to answer the questions listed above and especially to illustrate the tutorial's impact on participants' problem solving as well as the relationship between the questionnaire and individuals' search strategies. To this end, the design centered on a problem solving activity that focused on participants' use of some of Bates' (1979) idea tactics to support their information searches in library databases. These idea tactics discussed in Chapter one, represent metacognitive strategies and a modified version of twelve of these tactics was provided to the participants in an online tutorial format for their review in the study.

Analyzing users' incorporation of idea tactics as they solve an information problem underscores the objective of the dissertation because it highlights the role of

metacognition in information search. In its focus on a problem solving activity, the research shares similarity with work by Land and Green (2000) discussed in Chapter two that examined individuals' information problem solving strategies through the use of think aloud protocol, videotape observations, and ratings of final products. However, their research focused on teachers' information seeking practices on the web and also included individuals' self-report of their system skills. The current study focused on graduate students' problem solving in Ebsco databases and the research did not track individuals self-report of their system knowledge.

Metacognitive scaffold. The research design also included a metacognitive scaffold to illustrate its impact on enhancing students search strategies. In its focus on supporting students' metacognitive strategies while problem solving, the metacognitive intervention shares similarity to a study by Wolf, Brush, and Saye (2003) discussed previously. However, the users in Wolf, Brush, and Saye's (2003) work included middle school students, while this research centered on education graduate students. Moreover, the focus of the current research on older students' strategies to locate information for ill-structured problems in databases mirrored Huttenlock's (2007) doctoral study. In this instance, the author utilized an advance organizer as a metacognitive intervention for students' database searching. Still, this intervention, outlined in Chapter two, was offered in print format unlike the metacognitive tutorial that was available online.

Think aloud protocol. The study's research design required participants adopt a think aloud protocol strategy to enhance understanding of their information seeking behaviors. In this approach, detailed by Hoppman (2007) in Chapter two, users verbalized their actions as they completed online tasks. For the current research, the think

aloud protocol strategy provided a mechanism for chronicling participants' thought processes as they interacted with the tutorial, devised search strategies to support their problem solving, reviewed search results, and identified issues that impeded their progress.

Usability study. The research design resembled a usability study in its efforts to trace participants' abilities to locate information in the library databases for their problem solving activity. The research design, like Tenopir et al.'s (2008) usability study discussed earlier, considered users' feelings during the activity. Although the authors labeled these as positive, negative, and neutral feelings, participants' attitudes in this research design were not categorized and included their views toward the intervention as well as their satisfaction level with their search results. The current research design also identified themes that emerged during the activity that influenced individuals' problem solving. In addition, the research encompassed elements from Stephan, Cheng, and Young's (2007) usability study that tracked users' time for task completion and their satisfaction level in completing the task. However, the current research considered the time participants devoted to devising search strategies and reviewing results before and after exposure to the tutorial. Lastly, the research shared similarity to studies by Stephan, Cheng, and Young (2007) and George (2008) by incorporating the findings to improve the products' design. In this instance recommendations were made to enhance the functionality of the tutorial.

Sample-participants

A convenience sample was used in the study. Volunteers were solicited from graduate classes in instructional technology and education classes at the University

during the Fall 2011 semester. The participants consisted of eight students including two males and six females of various ages enrolled in a College of Education's graduate programs in a four-year public institution located in a metropolitan area in the Mid-Atlantic region of the United States. Individuals contacted the researcher to schedule a problem solving activity. Participants were provided access to the idea tactics tutorial following an initial search activity.

Students were encouraged to participate in both components of the study and signed the consent forms displayed in Appendix A. Participants were compensated for their time with a twenty-five dollar gift certificate from a vendor of their choice. This reward may have affected students' motivation for joining the study, but it remained a necessary component of the research to ensure optimal participation.

Research instruments

The research employed one instrument including the screen capture software Camtasia. The data collected by this tool and the timeline for its collection appear in Table 5. Camtasia served as a screen capture tool for tracking the audio and video recordings of participants' activities and hence illustrating the impact of the tutorial on individuals' search behaviors. An initial database search served as a pre-test of participants' use of database search techniques.

Table 5

Data Collection Procedures and the Timeline for their Collection

Instrument	Data Type	Timeline for Collection
Camtasia	Qualitative audio file & screen capture	During problem activities for initial and revised searches
Camtasia	Qualitative audio file	Post-activity interview

The Pilot Studies

The research included two pilot studies. The first pilot aimed to improve design of the tutorial. Two graduate students participated in this one hour pilot of the tutorial. In this instance the students searched various Ebsco databases for information on their research question. Following a review of their results, each student read the tutorial and initiated new searches on their topics. At the pilot's conclusion, both students noted improvements in the relevancy of their search results following exposure to the tutorial. Still, follow-up interviews with the pilot study participants coupled with a review of the Camtasia files that contained the event's screen capture and audio recording, identified areas for improving the learning tool.

Pilot participants experienced difficulty navigating the main index page that they attributed to the lack of outcome headings such as relevance, evaluation, numbers, and strategy. One of the participants commented she wanted to "quickly review the index and determine where to go next." In addition, on the strategy, number, relevance, and evaluation index pages, the participant suggested matching the text color of the tactic headings to the definitions to promote readability.

The pilot study also revealed the need for the inclusion of learning objectives on all of the search example pages. Both of the study participants commented on their inability to determine the key concepts of the page. Both participants suggested this information appear at the top of the page where they could "immediately know what I'm supposed to get from the example."

A review of the Camtasia files supported improving the navigation and design of the tutorial. The files also illustrated the need to emphasize the importance of subject

terms in enhancing the relevancy of the results since participants appeared reluctant to utilize this search strategy. While reading a search example page one of the participants remarked "So this says to use subject terms but I'm not exactly sure what the difference is." The other participant referred back to the tutorial several times during her search in an effort to improve her results. In the follow-up interview she suggested the tutorial highlight the definitions for subject terms and truncation.

Consequently the researcher, working with a web design expert, modified the tutorial's interface to enhance its readability. These enhancements focused on reducing image sizes and dense text on all of the index pages. For example, the lengthy description of the lesson outcomes on the index page was replaced with mouse over text. To improve navigation from the main index, four headings were created to guide readers to the appropriate page. These headings were situated along the left size of the page since web usability studies support reading from left to right. Likewise, a title was added to each search example page that listed the tactic and its focus to facilitate navigation and comprehension of this component of the tutorial. Lastly, the content on these pages were revised to include explanations of subject terms and truncation for each instance of its utilization in a search.

The second pilot in late August provided a final opportunity to test the tutorial. One education graduate student volunteered for the test. In this instance the participant was provided the laptop that contained the tutorial, Camtasia, and access to the Ebsco databases. The student conducted her initial search, skimmed the tutorial's index pages and focused on the Change tactic example since she hoped to reduce the number of her hits. She subsequently revised her search adopting the tactic example's suggestion to

include more keywords to narrow the focus of her search. Her results decreased from 244 to 14 hits. Although, she examined the Evaluation and Strategy Indexes pages for additional ideas, she opted not to search again noting all of her articles were relevant to her topic and would support her teaching.

The Tutorial

The researcher created the tutorial with the assistance of a senior reference and instructional librarian at the University who served as a consultant in the development of the tool. The initial design objective centered on providing a description of Bates' idea tactics. However, the tutorial's developers latter opted to include database search techniques to underscore the application of Bates' idea tactics during problem solving in digital libraries. In addition, they hoped to support participants' search activities in the Ebsco databases. Consequently search examples offered information on Boolean operators, selecting databases, limiting results, choosing keywords, using subject terms, truncating words, evaluating results, and considering synonyms. Some additional material was provided on specifying methodologies, as well as utilizing Ebsco's "times cited in this database" and "related records" features.

The tutorial centered on the Main Index (Figure 3) that contained links to four additional indexes that represented common obstacles users encountered during information search including: relevance, number, evaluation, and strategy. These indexes were designed to direct users to the appropriate page to improve their search outcome. Each of these indexes described three idea tactics and they contained links to example searches. Figure 4 displays a screen shot of the Number Index.

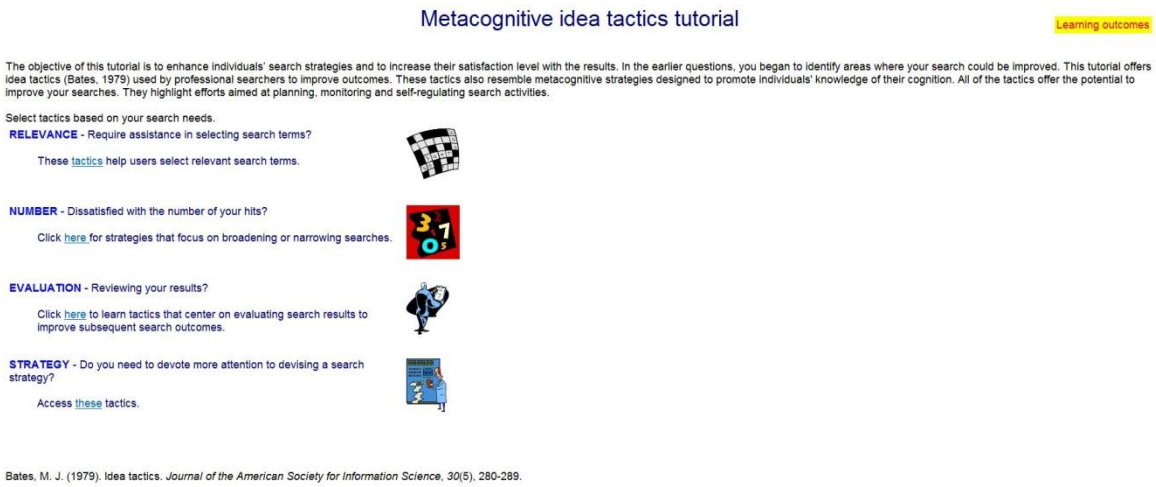

Figure 3. Main Index of the Idea Tactics Tutorial.

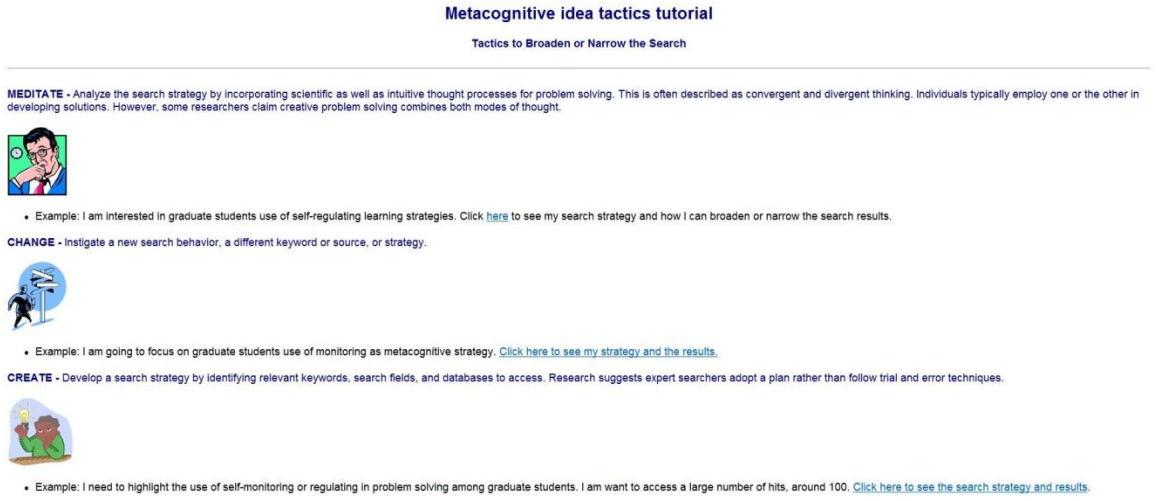

Figure 4. Number Index of the Idea Tactics Tutorial.

Each of the four Index pages provided access to database search examples that highlighted idea tactic strategies. These examples were aimed at providing users an overview of various database features available in Ebsco as well as strategies to enhance search results. All example search pages contained titles as well as learning objectives and database screen shots. Figure 5 displays the Meditate tactic example.

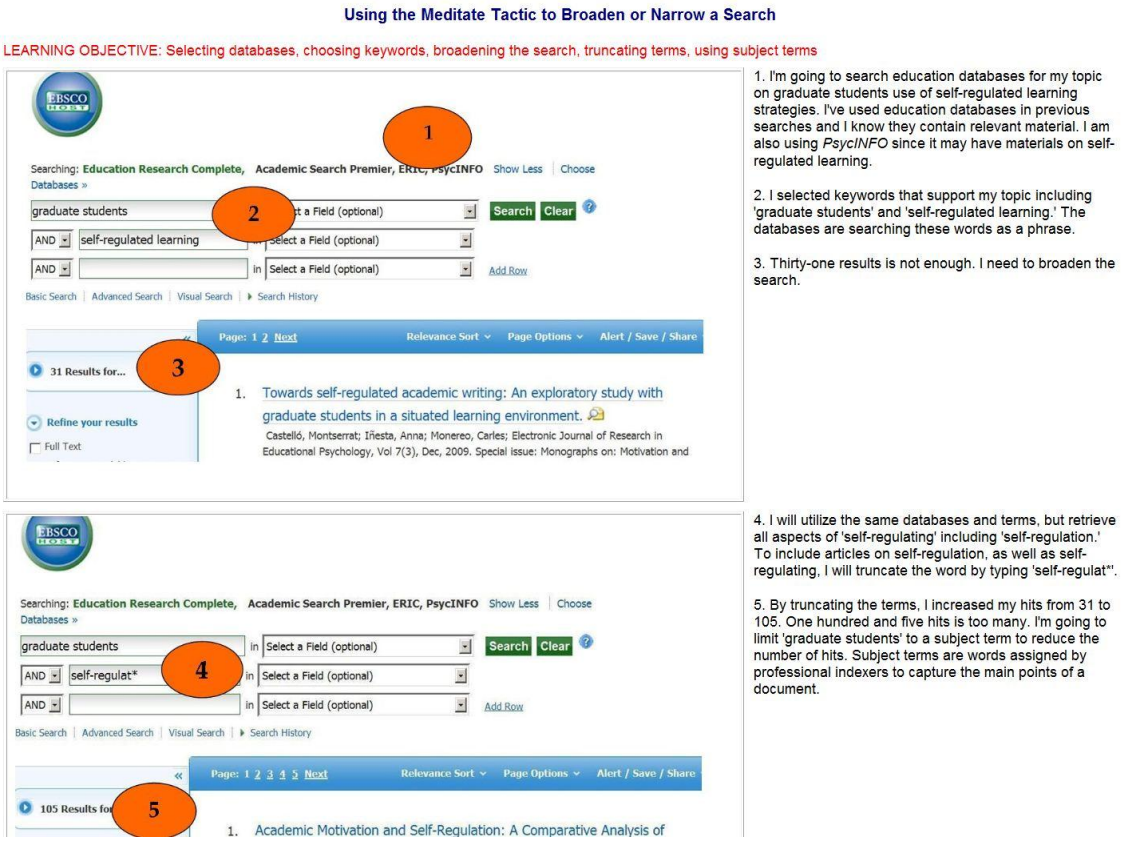

Figure 5. Meditate Idea Tactic search example.

The think-aloud problem solving activity and post activity interview

A College of Education conference room at the University served as the location for the think aloud problem solving activities and the post-activity interviews. The researcher utilized a laptop that contained Camtasia as well as the tutorial enabling participants the ability to access all components of the study including the library's subscription databases from one devise. A mouse was also available for use with the laptop if desired by the participants. At the start of the activity individuals produced their information problem. This was a topic that remained meaningful to the participants and it typically was a course assignment. The study utilized participant generated information problems to increase the incentives for volunteering and also to maintain individuals' interest throughout the activity. On the problem solving activity day, the researcher began

the process by describing the study including: an explanation of purpose of research, information concerning the video and audio recordings, and an assurance the results will be confidential. Participants signed a consent form and were provided an opportunity to ask for clarification of any of the components of the study (Appendix A).

Students were instructed to locate materials for their problem using the Ebsco databases on the library's web page. They verbalized all of their movements through a think aloud protocol as they gathered information for their topic. Following one or two initial searches, each participant responded to evaluative prompts that tracked the individual's satisfaction level with the various aspects of the search such as the number of results and the relevancy of the material. These prompts aimed to guide participants in adopting appropriate revision strategies for subsequent searches. At this point the idea tactic tutorial was introduced for participants to review. The participant instituted additional searches on their topic following exposure to the tutorial. After conducting the search, the participant again responded to the evaluative prompts and conducted revised searches until they appeared satisfied with the results or opted to stop searching. Participants were encouraged to think aloud and consult the tutorial if they were not satisfied with their search results. Participants' revised search time did not exceed 30 minutes.

The screen capture software created a video of participants' voices throughout the task and their cursor movements. This allowed for an examination of the search terms, menu selections, databases chosen, search strategies, and result sets as well as their comments during the task. The files were saved in Camtasia's default file format camrec.

Follow-up interviews. The researcher conducted semi-structured interviews following each task completion portion of the activity (Appendix B). These interviews enhanced interpretation of the think aloud protocols by allowing participants an opportunity to provide an explanation of their research strategies during the session including any obstacles they encountered as well as their satisfaction level with the search results. All interviews were audio-taped and transcribed verbatim by the researcher.

Data analysis

A variety of tools and procedures were utilized for the data analysis. Foremost the researcher sought to maintain the integrity of the data and the confidentiality of the participants, while promoting the validity and reliability of the findings.

Transcripts problem solving activity-prefigured codes. The researcher followed the ethnographic approach outlined by Pink (2007) in the analysis of the transcripts from the problem solving activity and post activity interview. Pink described ethnography as a "process of creating and representing knowledge (about society, culture, and individuals)" that remains as accurate as possible to the context "through which the knowledge was produced" (p. 22). She noted the outcome was affected by the attitudes and views of the researcher and the subject as well as their relationship to each other. Consequently she advocated a reflective approach that highlighted the contexts of the video's production and especially the "subjectivities and intentions of the" participants (p. 123).

To that end, the interpretation of the think aloud protocol Camtasia files in camrec format were transcribed and coded (Appendices C and D). The problem solving

transcripts were coded using pre-figured codes based on Bates' (1979) idea tactics that were listed in the tutorial including all of the Indexes as well as the tactic examples to track participants' use of the tactics. For example, participants' views of a specific index page, such as the Evaluation Index, and subsequent efforts to evaluate results to improve outcomes in their revised search, led to the coding of the transcript as "application of Evaluation Index." Likewise, participants' views of the Change tactic example as well as comments about the tactic were coded "comments about the Change example and participants time spent on the page." Frequency counts recorded participants' number of accesses to the various components of the tutorial as well as the length of time they spent in each section. The number of seconds participants devoted to devising strategy and reviewing results was also recorded using a stop watch.

Transcripts- problem solving activity & post-search interviews open coding schemes. The researcher also coded the transcripts from the problem solving activity and post-search interviews utilizing an open coding scheme to capture the issues that emerged during participants' problem solving activities (Creswell, 2007). The researcher adopted the constant comparative method outlined by Glaser and Strauss (1967). This method focuses on numerous comparisons among transcripts to ensure accuracy in the identification of codes. Coding remains an iterative process that includes creating, merging as well as the elimination of codes. The authors identified four stages in the method including: comparing comments or actions in categories, integrating categories, developing theory, and writing theory. Theory development in this instance required the researcher to consider an abstract perspective in analyzing the qualitative material (p. 114). In the current study codes were developed considering themes characteristic of

information search. The researcher identified commonalities among the transcripts and developed codes accordingly. This information highlighted the search activity, problems participants encountered in the process, participants' views on the search tactics they utilized, techniques they employed in their problem solving, their satisfaction with the search results, and any additional information they chose to offer.

Coding occurred in several phases by two individuals, the researcher and a co-evaluator, both reference librarians, to support inter-coder reliability. Initially the researcher reviewed each line of every transcript to identify various idea tactics and dominant themes that emerged during the activity and post search interview. The researcher reviewed and compared transcripts numerous times to ensure the accuracy of the content as well as the context in developing the codes. This facilitated the creation of the code tree (Appendix C) that illustrated relationships among codes. For example, the themes that emerged for the initial search among all the participants included: choose databases, results review, and initial strategy. On the other hand, in reviewing the results of their revised search participants focused on interest, subject terms, keywords, page length, refinement of concept terms, filtering, full text availability, and the number of results.

Following the identification of the codes, the researcher provided all of the transcripts as well as the codes to the co-evaluator for his comment and suggestions. The co-evaluator, one of the University's senior reference librarians with experience in NVivo coding, noted some inconsistencies and provided suggestions for the renaming of some codes and the creation of additional codes for several categories. For example, he recommended placing "errors" under "Search Obstacles" and dividing errors into

"initial," "continuous," and "Ebsco". This suggestion was adopted with one modification. The "obstacles" node was changed to "Participants Perspectives-Search Obstacles" and the "Errors" node was placed under "Search" following discussion between the researcher and co-evaluator. In addition, the "Instruction" node was deleted since it was represented in "librarian" under "Reflections-General".

NVivo. NVivo version 9 qualitative analysis software facilitated the coding process. The software contained the ability to facilitate code assignment by importing transcripts and searching text for keywords or phrases. Another feature of this product allowed users to track their coding processes through the creation of code definitions. Special attention was focused on creating the index or tree system that illustrated relationships between codes. This software was purchased and loaded on a laptop and provided to the co-evaluator.

Participant searches. Transcription of the Camtasia files allowed for a recreation of participants searches (Appendix E). In this instance each search participants performed was recorded including the syntax, keywords, and databases utilized as well as the number of results received. The inclusion of [YOUR] after the search string indicated the query did not yield any hits and Ebsco reverted to Smart text searching to return results based on keywords.

Final product. The co-evaluator also assisted with the rating of the search results from the problem solving activity. This represented the outcomes for all of participants' search results from their Ebsco database searches including those performed before and after exposure to the tutorial. The researcher and the co-evaluator rated each search using a five point Likert scale (Appendix F) based on the results' relevance, its

authoritativeness, the quality of the response, and its ability to answer the problem. A five represented the highest ratings. Evaluators gauged the relevance of the search results by how closely the articles matched the topic. The authoritativeness of search results was determined by the scholarliness of the articles, but since participants were searching an academic database, all search results, except zero, received a baseline rating of three. Individuals that checked scholarly or peer reviewed materials received higher scores.

Quality of the response was judged according to a variety of factors including : improvement occurred over a previous search if available as well as the number and cohesiveness of the topic in the results. Lastly, evaluators considered the results ability to answer the problem. Rating of the search results occurred in two phases. In the first phase the researcher viewed the search results from the Camtasia files. In the second phase, the researcher recreated the search utilizing the same keywords, search techniques, and databases employed in the participants' initial search. Searches were rated based on these results as well as the results the participant received during the activity. The information was provided to the co-evaluator for his review and comment. Comparisons between the first search and the last search determined the degree of improvement following access to the tutorial. If participants conducted numerous searches prior to accessing the tutorial, the average ratings of these events were utilized for the first search scores.

The ratings for all of the participants' first and final searches were transcribed and appear in Appendix G. The databases participants accessed as well as their search syntax, keywords, and the number of results they received are also displayed. .

Statistical Package for Social Sciences (SPSS). Bar charts and scatter dot plots were created using the SPSS software (Appendix H). The researcher utilized the

following data to create the diagrams including: the total number of accesses to the tutorial, the total time in tutorial, the total time devising search strategy, the total time reviewing results, the number of revised searches, the number of records opened, as well as the search scores for relevancy, authoritativeness, the ability of the responses to answer the question, and the quality of the response for the initial and final searches. Diagrams relevant to the findings are included in Appendix H.

Construct Validity

Construct validity refers to how well an experiment supported its objective. Shadish, Cook, and Campbell (2002) suggested construct validity was promoted by "clear explication of the person, setting, treatment, and outcome constructs, carefully selecting instances that match constructs, assessing match between instances and constructs, revising constructs descriptions if necessary" (p. 66). In addition to these considerations, construct validity in this research was facilitated by the triangulation of the data and especially in comparisons made among the various data types. (Creswell, 2007, p. 45). Shadish, Cook, and Campbell (2002) also promote triangulation emphasizing "the need to use multiple operations to index each construct when possible, multiple measures, manipulations, settings, and units" (p. 81). Likewise they encourage insurance that the multiple operations "reflects multiple methods so that single method confounds can be better assessed" (p. 82). In the current study, the data included quantitative and qualitative from the think aloud protocol, screen captures, the post-search interviews, and the scoring of the first searches and last search. The validity of the findings from the quantitative data stemmed from its triangulation that included data on the number of revised searches conducted, the time spent devising search strategies and

reviewing results, the number of records opened, the number of results, the number of accesses to various components of the tutorial, and scores on participants' search results. The triangulation of the qualitative component included information from the think aloud and the screen captures as well as the post-search interview.

Validity for the qualitative component of the study focused on the Camtasia files that recorded each participants' problem solving activities. Transcripts from the think aloud protocol activity supported the validity of the qualitative data by revealing participants' thoughts and motivations in utilizing search strategies and the tutorial during their problem solving activities. In addition, the post-search interviews provided a reliability component through their focus on identifying participants' motives in their search strategies, their satisfaction level with the results, as well as any obstacles they encountered during the problem solving process.

The initial search served as a control measure for illustrating the impact of the tutorial on individuals' problem solving behaviors and the triangulation of the material that included both qualitative and quantitative measures strengthened the findings. Validity was also strengthened by comparisons among the various data types. For example, participants' search behaviors in the initial search including search techniques utilized, databases accessed, and scores for relevancy, quality, appropriateness, and authoritativeness of the results were compared with their strategies utilized in subsequent revised searches after exposure to the tutorial.

Lastly, intercoder agreement supported the validity of the transcripts in the code assignment process and the search score ratings. The researcher and a co-evaluator, both librarians, mutually agreed on the creation of the codes. The use of the NVivo software,

and especially the code descriptions that allowed the researcher to describe the definition of each code, strengthened the validity of the process (Appendix D). Intercoder reliability was also used for the rating assignment of all the search results. In this instance each search outcome was assigned a rating for the results' relevance, its authoritativeness, the quality of the response, and its ability to answer the problem (Appendices F and G).

Conclusion

Kuhlthau (1991) noted users' anxieties when seeking information and promoted the provision of support as they progress through various stages of the process. This research evaluated the effectiveness of an idea tactic tutorial as a metacognitive intervention to foster education graduate students' development of search strategies to support their information seeking behaviors in digital libraries. An earlier study by Blummer, Lohnes, and Kenton (2009) revealed students desired different types of library training. In this instance, students may benefit from instruction in applying various idea tactics or metacognitive strategies to enhance their web and database searching. Lazonder and Rouet (2008) pointed to supporting metacognition through instruction and the development of prompts. To this end, this research promotes an instructional tool that provided metacognitive strategies to improve users' search behavior while solving information problems. Ultimately, the research results will be used to further improve the design of the tutorial thereby enhancing its effectiveness in developing users' metacognitive strategies during their information seeking activities in digital libraries.

IV. FINDINGS

This chapter describes the problem solving activities of the participants. Pseudonyms were used to protect the privacy of the participants. The descriptions center on the research questions including what search techniques participants demonstrated in their first search, what type of experiences individuals had with the tutorial and how tutorial affected search outcomes. A summary of each participants' search experience is presented including information from their post-search interview and think aloud. An overall illustration of the group experience in the problem solving activity is also included.

Participants

The research participants consisted of eight individuals enrolled in masters programs and doctoral study within the College of Education at a mid-Atlantic University. The group included six women and two men who ranged in age from 22 to 51 years old. These eight individuals were self-selected and they received a $25 gift card for their participation in all three components of the study. Despite the monetary award, all participants remained eager to gain additional database search skills and especially to obtain materials for their course assignments.

Dwaine

Dwaine was a male in his late thirties. He had some knowledge of educational databases. Table 6 illustrates his familiarity with the various databases offered through

Ebsco. He was interested in classroom observation tools for technology integration in the classroom.

What search techniques did participants demonstrate in their initial search?

After explaining his topic, Dwaine indicated his first step was to choose his databases. At this point he added Education Research Complete to the default database Academic Search Premier and remarked "I think that's it for now." Table 7 lists the time Dwaine spent devising his search strategy that totaled nearly two minutes. He proceeded to type in the search box "classroom observation tool technology integration" using Ebsco's basic search mode. He received over 13,000 hits. Dwaine reviewed the results for nearly a minute and said they were "too broad" and included topics he was not looking for.

Table 6

Search Strategies Dwaine Demonstrated in His Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial					1		
Post-tutorial	1		2	2	1		

Note. Includes number of instances of strategies.

Table 7

Time Dwaine Spent Devising Search Strategies and Reviewing Results

Search	Devise Strategy	Review Results	Number of Hits	Open Records	Tutorial Access
Initial Time	87 seconds	56 seconds	13,151		See Table 8 row 1
2nd Search	31 seconds	76 seconds	20	1	See Table 8 row 2
3rd Search	24 seconds	25 seconds	1		

Note. The number of hits he received and the number of records he opened are also displayed.

What type of experiences did participants have with the tutorial?

Dwaine's experiences in the tutorial centered on the Change tactic and this is outlined in Table 8. Dwaine spent about a half minute reading the Tutorial's Main Index. He explained he was "going to click on the link for dissatisfied with the number of hits because 13,000 is too much." He then read the Number Index and remarked "I'm going to the first example here Meditate I guess, no wait I want to Change." He read this example for approximately 1 minute.

Dwaine revised his search, utilizing the advanced search mode and new terms. He reduced the number of his hits to 20 items. Dwaine devoted over a minute to reviewing these results and appeared dissatisfied with the hits noting "What I am really looking for is information on tools used to evaluate technology integration in the classroom and I'm still not finding that. Actually here is one." At this point he examined a record, but remarked "The tutorial told me I could look at keywords in an article that actually looked relevant and use that in my search."

Dwaine's confusion led him back to the tutorial. He re-read the Change tactic

example but suggested all he could find was information on subjects. Still, he explained his intention to use "one of these keywords as subjects since this article is relevant." Dwaine modified his search terms and his new strategy provided his a smaller and more relevant result set.

Dwaine read one tutorial tactic to gather information to improve his search results. He referred back to this tactic once to clarify information about using keywords. Although he only accessed the tutorial twice, he spent nearly four minutes in the tool. He also spent about a half a minute reading the Main Index. This component of the tutorial provided information about metacognition and the other parts of the intervention. Dwaine focused on the Change example, as Table 8 reveals, and he did not view any of the other tactic examples.

How did the tutorial affect outcome of the problem solving activity?

Dwaine employed search techniques presented in the tutorial including employing Boolean operators, locating terms from relevant articles, and utilizing the advanced search mode in his subsequent searches (Appendix E, E.1 Table 1). Dwaine's first revised search incorporated Ebsco's advanced search mode with the Boolean AND operator. The Change example contains Ebsco database screen shots that illustrate Boolean operators. The Change tactic urged readers to instigate a new search behavior, a different keyword or source, or strategy. Dwaine's comments during the think aloud component of his search suggested he incorporated the Change tactic's advice. "Okay despite the fact the tutorial, from what I could tell, did not tell me to click advanced to get these AND fields, I figured that out. Now I am going to try to change the wording of my search." His

Table 8

Dwaine's Time in Seconds in the Tutorial

Cycle	Main	Number				Relevance				Evaluation				Strategy		
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	38	69		60													
2nd				63													

Note. Includes the number of his accesses to various components of the tutorial.

keywords were “classroom observation” and “technology integration” and he used the Boolean operator AND. Upon reviewing his 20 results he commented “That’s much closer.” Still, he examined the terms used in a relevant record to obtain keywords for another search. After reviewing the results he modified his search substituting the phrase “technology assessment” for “technology integration” that he obtained from a reviewing a relevant record. He received four results that he indicated were useful. “Okay out of these four results I would say 3 of them would be exactly what I was looking for.”

Post-search interview

In his post-search interview Dwaine said he was “very satisfied with the results” from the problem solving activity commenting “For now I would be happy.” He noted his intention to get additional citations from the sources’ references. According to Dwaine “One of these is from a book so I have a feeling there would be quite a few citations named.” He stated the tutorial helped him narrow down his search and taught him about looking at the keywords. “I guess I didn’t really think at looking at the keywords.” However, Dwaine said he was confused about some of the terminology in the tutorial as it related to the Ebsco database. Dwaine indicated the tutorial talked about keywords, but he did not see keywords in the records only subjects. “It took me after a couple of minutes to realize that’s probably what the tutorial meant by keywords, was the actual subjects.” Dwaine stated he did not have any problems with the think aloud protocol or utilizing the laptop.

Summary

Dwaine’s search strategies following access to the tutorial suggested he had gained search skills from the intervention. In his revised searches, he demonstrated

knowledge and use of the advanced search mode and the Boolean operator AND. These techniques he did not use in his initial search. In the post-interview component of the think aloud, he attributed the tutorial to highlighting the value of using keywords from an article that was relevant. To this end, his revised search incorporated a new keyword from a relevant hit. Dwaine observed "I didn't know exactly what was good to solicit in the results I wanted."

A comparison of the ratings between Dwaine's first search with his final search illustrated increases in relevancy, the ability to answer the problem, and the quality of the response from average and below average to above average in all categories (Appendix G, Tables 1a and 1b). His final search scores are revealed in Table 9.

Table 9

Dwaine's Final Search Scores.

Category	Failed	Below average	Average	Above Average	Excellent
Relevant				4	
Authoritative				4	
Answered Problem				4	
Quality of Response				4	

In addition, Table 7 shows that Dwain searched more efficiently after exposure to the tutorial. He spent less time devising search strategy in his two revised searches, but his final search results had higher relevancy scores compared to his initial search outcome. In addition, Table 7 reports Dwaine spent more time reviewing results following access to the tutorial. As Dwaine revealed during the think aloud component of the search, he was seeking relevant keywords to apply in his revised strategy.

Although Dwaine was satisfied with the four results in his final search, he could have increased his number of hits by truncating assessment and expanding his databases

to incorporate Eric. Still, as the co-evaluator noted Dwaine received a small number of "well-focused" hits and made the "best use of the tutorial." In this instance, Dwaine focused on reading one tactic and implementing the search suggestions presented in the example.

Amy

Amy was a quiet young woman in her late twenties. Her soft spoken nature affected her think aloud protocol as she did not always explain her actions. Amy's topic centered on reading activities for first grade students and she was eager to obtain materials to support her teaching. Amy did not demonstrate any knowledge of advanced search skills in her first search.

What search techniques did participants demonstrate in their initial search?

Amy did not use any advanced search techniques in her initial search (Table 10). In addition, she spent less than 20 seconds devising her search strategy for the initial search shown in Table 11. In her initial search she typed "reading activities first grade" into Ebsco's basic search mode using the default database, Academic Search Premier. She obtained one result.

Table 10

Search Strategies Amy Demonstrated in Her Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial							
Post-tutorial		1	2	2			

Note. Includes the number of instances of search strategies**.**

Table 11

Time Amy Spent Devising Search Strategies and Reviewing Results

	Devise Strategy	Review Results	Number of Hits	Opened Records	Tutorial Accesses
Initial Time	19 seconds	25 seconds	1		See Table 12, row 1
2nd Search	28 seconds	45 seconds	18,344		See Table 12, row 2
3rd Search	39 seconds	0 seconds	0		
4th Search	18 seconds	527 seconds	22	7	See Table 12, row 3

Note. The number of hits Amy received and the number of records she examined are also reported.

What type of experiences did participants have with the tutorial?

Amy's overall time in the tutorial was brief, a little more than two minutes (Table 12), although she accessed the tool in three separate instances. In her first foray into the tutorial, she quickly scanned the tutorial's Main Index before selecting the Number Index and then reading the Change tactic example. This led her to revise her search to include broader concepts for some of her terms. For example she substituted "literacy" for "reading" while spending nearly a half minute devising the search strategy and almost twice as long reviewing her results. After this search yielded over 18,000 hits, she returned to the tutorial and re-read the Change tactic example. Amy returned to the search screen, but before beginning another search, she opted to re-read the example again. She spent more time devising her strategy for this search that included use of subject terms. Her strategy produced no results, but when she changed the field from subject to all text and she received 22 hits (Appendix E, E.1 Table 2). Amy accessed the tutorial one final time re-reading the Change tactic example and briefly browsing the Number Index to locate information on how to filter her results.

The tutorial appeared to serve as a reference tool for Amy to improve her search strategy and outcome. Although she accessed the tool on three separate instances, she remained within the Number Index's Change tactic and focused on gathering strategies presented in the example such as using Boolean operators and subject terms (Table 12). After her first two accesses to the tutorial, she implemented new strategies and received better results compared to her initial search. In her final access to the tutorial she sought information on how to narrow her results. "Is there a way I can filter through, like if this is not relevant?"

How did the tutorial affect outcome of the problem solving activity?

Amy demonstrated use of search techniques presented in the tutorial in her subsequent searches that improved the outcome of her problem solving activity as Table 10 reveals. For example, in her post-tutorial searches she demonstrated use of subject searching, Boolean operators, and the advanced search mode. These techniques were not reflected in Amy's initial search. In her first revised search Amy typed in "early literacy reading activities for a first grade student" in the search box using Ebsco's basic search mode. The screen display indicated her search did not yield any results, but using smart text searching she received over 18,000 hits. In this case Ebsco treated the words as a phrase and returned results based on the keywords. In revising this search she selected the advanced search mode using the terms "reading activities" and "first grade student" in the subject field with the AND Boolean operator. Although her initial revised strategy yielded no results, when Amy changed "first grade student" from a subject search to an all text field, she obtained 22 hits. She spent the remainder of the activity reading the results' titles and determining their relevancy to her topic.

Table 12

Amy's Time in Seconds in the Tutorial

Cycle	Main	Number				Relevance				Evaluation				Strategy		
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	9	19		21													
2nd				54 (2)													
3rd		15		10													

Note. Includes the number of accesses to the tutorial.

Post search interview

In her post-search interview Amy stated that she was satisfied with the results she obtained from her problem solving activity. She said that the tutorial instructed her in how to perform a subject search. She also said it was helpful with "a lot of the phrasing" in her searching. She suggested the obstacles with her search centered on finding an optimal number of results. "Well, I first typed in a long phrase and came up with hardly anything at all." According to Amy, some searches yielded "way too many" but "one was not enough and "then I found just the right number." Amy indicated she did not have any difficulties with the tutorial or the think aloud protocol.

Summary

An analysis of Amy's problem solving activity highlights the effect of the tutorial on improving her search results for the number of hits as well as the relevancy of the results. In addition to adopting the Change tactic example's suggestion to instigate a new search behavior, she also incorporated some database search techniques described in the example into her revised search. For instance, in her subsequent searches Amy demonstrated knowledge of the advanced search mode, Boolean logic, and the subject search option. She appeared to understand the impact of keywords on the relevancy of the results. Scores for her last search were four in all categories and that represented an overall improvement especially in the ability to answer the problem and quality of the response (Appendix G, Tables 2a and 2b). In addition, comparisons between the amount of time she spent in devising search strategies and reviewing results increased following her access to the tutorial after her initial search (Table 13). She also viewed seven records

during the post-tutorial phase of the problem solving activity compared to none of her initial search results.

Amy's search strategy would have benefited from efforts to expand her databases to target educational materials such as Eric and Education Research Complete. This would have increased the relevancy of her results. However, using these databases significantly expanded the results set for Amy's search "first grade student (all text)" and "reading activities." Still, the number of hits could be reduced by searching "first grade student" in the select a field option rather than an all text field as Amy had employed, increasing the relevancy of the hits while decreasing the number of results.

Lesley

Lesley was a young woman in her late twenties. She appeared nervous and seemingly unsure of her search abilities. She also expressed concern about when to stop searching and indicated she wanted "quality not quantity." Her topic was mindfulness in young children.

What search techniques did participants demonstrate in their initial search?

Lesley's initial attempt was a basic search in Ebsco using the default database Academic Search Premier and the phrase "mindfulness and young children". The search yielded four results. Table 13 depicts the database search skills that she used in her first search. Following her initial search, she considered limiting her results pointing to the left hand side of the display page and stating "The problem is the sources here."

Although Table 14 highlights the lack of time she devoted to devising her initial search strategy, it shows she did review her results for nearly a minute. She explained she did not choose any databases "because I just wanted to see what I can get." Although, she

recognized the need to expand her search to receive more hits, she described some of the results as relevant especially one titled “Exploring the feasibility and benefits of arts-based mindfulness-based practices of young people.” According to Lesley “that’s what I’ll be doing if I teach in the inner city like I want to.” On the other hand, she observed one result was about parenting and that wasn’t “relevant.”

Table 13

Search Strategies Lesley Demonstrated in Her Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial							
Post-tutorial	1		7	7	1	4	5

Note. Includes the number of instances of search strategies

Table 14

Time Lesley Spent Devising Search Strategies and Reviewing Results

Search	Devise Strategy	Review Results	Number of Hits	Opened Records	Tutorial Accesses
Initial Time	18 seconds	57 seconds	4		See Table 15, row 1
2nd Search	20 seconds	9 seconds	231		
3rd Search	19 seconds	14 seconds	207		
4th Search	36 seconds	8 seconds	231		
5th search	10 seconds	56 seconds	207		
6th Search	23 seconds	0 seconds	0		
7th search	17 seconds	38 seconds	1		See Table 15, row 2
8th Search	41 seconds	30 seconds	170		
9th Search	14 seconds	38 seconds	153		
10th search	12 seconds	62 seconds	66		
11th Search	16 seconds	61 seconds	19		
12th search	12 seconds	13 seconds	66		See Table 15, row 3
13th Search	61 seconds	1 minute 42 seconds	24		
14th Search	12 seconds	9 seconds	7		

Note. The number of hits she received and the number of records she examined are also reported.

What type of experiences participants have with the tutorial?

Lesley accessed several tactic examples in the Number Index as Table 15 reveals. In her initial encounter with the tool she spent 31 seconds reading the Main Index and noted she was going to start by trying to increase the number of her hits. To this end she accessed the Number Index and spent a significant amount of time reading the page. She also examined the Meditate example. She returned to the Number Index and re-read the page before viewing the Change and Create tactic examples. She returned to the search screen and revised her search six times. Following each search she focused on reviewing her results, rather than devising search strategies that included substituting terms for various concepts and narrowing her results using dates and limiting to peer-reviewed

Table 15

Lesley's Time in Seconds in the Tutorial

Cycle	Main	Number				Relevance				Evaluation				Strategy			
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	31	97(4)	133	60	33												
2nd		14	18														
3rd			77														

Note. Includes her number of accesses to the tutorial components.

materials. When these searches yielded over 200 hits, she incorporated terms to narrow the number and focus of her search including “kindergarten” and “public school.” The lack of results for these searches prompted her return to the Number Index and the Meditate tactic example. Although she did not spend much time reviewing the example, upon returning to the search screen she changed her database to Education Research Complete. The Meditate example promotes the use of educational databases. She revised her search an additional five times incorporating more terms and employing narrowing tactics described in the example such as truncation. She spent the bulk of her time reviewing results, rather than devising strategies. Following her fifth search, Lesley re-visited the Meditate tactic example for nearly two minutes. This led Lesley back to the search screen to employ nearly all new search terms.

Lesley initially appeared to view the tutorial as a learning tool to expand the number of her initial hits. However, as her problem solving activity progressed, she depended on the tutorial as a reference source to obtain additional ideas to improve her search. Although she accessed the tutorial three times during the activity, she remained within the Number Index and read all of its tactic examples. Lesley employed many of the suggestions described in the tactics and the examples.

How did the tutorial affect outcome of the problem solving activity?

Lesley performed 13 revised searches during her problem solving activity (Appendix E, E.1 Table 3)**.** In her first revised search, Lesley maintained the keyword “mindfulness” but substituted “early childhood education” for “young children”. In this instance Ebsco defaulted to phrase searching and utilized smart text searching to provide 231 results. Following this effort, Lesley went to the advanced search screen and

performed the identical search but narrowed her results to peer reviewed materials. This did little to improve her search results that exceeded 200 hits. She spent the remainder of her problem solving activity experimenting with efforts to reduce these hits substituting various keywords including “kindergarten”,“public”,“teach” and “class.” She also employed narrowing options such as specifying dates, limiting to scholarly peer reviewed materials, and expanding her database selection to include Education Research Complete. Her most successful strategy was performing an advanced search using Boolean operators and truncating terms. This search “mindfulness” AND “teach* AND “class* yielded 24 results. Table 11 illustrates the search techniques she gained during the problem solving activity.

Post-search interview

In her post-search interview, Lesley said she liked the tutorial because “it has enough information to actually help someone thinking, but it wouldn’t take too long to get through.” She identified obstacles to her problem solving activity as selecting relevant search terms that “get me to where I want to go without boxing me in.” She explained her desire for as many things to choose from as possible. “I just want to learn about it and see if the things I am interested in are connected in other people’s minds.” She also admitted to some difficulty with the think aloud protocol. “It was unfamiliar to me. I wasn’t sure if I was supposed to be talking to you to no-one. I do think about what I am doing most of the time.”

Summary

Lesley included many of the tutorial’s tactic’s suggestions in her revised searches such as: experimenting with keywords, adopting new search strategies, and utilizing

educational databases. She also incorporated many of the database search techniques described in the tutorial in her these searches such as using the advanced search mode and Boolean logic, employing truncation, as well as limiting to peer reviewed materials, and specifying dates. Lesley had previous exposure to some of these search techniques in a library skills instructional class at the University, but she stated it was "still new" to her. She also followed the tutorial's advice to examine records for relevant search terms pointing out "I know I could probably go into one of those better articles and see what terms they use." In another instance she commented "I'll look at one article just to see what terms are listed there." Table 12 shows that she did not review any records for relevant keywords, but she did examine the titles carefully for appropriate search terms to include in her revised searches.

During the activity, she noted she was getting some relevant materials from the search experience "A few really good ones I feel like gems." In commenting on the quality of her final search she remarked "These are the kind of articles I would probably be looking for." A comparison of her first search with her last search revealed the impact of the tutorial on her problem solving activity (Appendix G, Tables 3a and 3b). She gained improvements in relevance, ability to answer the problem, and quality of the response for the scores of her search results. In addition, comparisons between the time she spent devising search strategies and reviewing results increased following her exposure to the tutorial for some of her searches (Table 12).

Lesley's topic would have benefited from including educational and related databases such Education Research Complete, Eric, and PsycInfo in her search strategy. Using these sources, employing subject terms for mindfulness and including the terms

teach* and child* yields a significant number of relevant results.

Betsey

Betsey was new to the master's program as well as the University. Although she was the youngest participant in the study at 22 years old, she appeared confident in the search environment. However, she admitted she had never used Ebsco. Her topic was the immigration of English language learners.

What search techniques did participants demonstrate in their initial search?

Table 16 lists the database search techniques Betsey used in her first search. In her initial search she performed a basic search using the default Ebsco database, Academic Search Premier with the phrase "immigration of ELLs". She obtained 2 results. She conducted another search using the advanced search mode and incorporating the term "Maryland." That search remained unsuccessful yielding no hits (Table 15). However, the Table 17 depicts the extensive amount of time Betsey spent reviewing her results.

Table 16

Search Strategies Betsey Demonstrated in Her Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial			1	1			
Post-tutorial			4	4	2	1	

Note. Includes the number of instances of search strategies.

Table 17

Time Betsey Spent Devising Search Strategies and Reviewing Results

Search	Devise Strategy	Review Results	Number of Hits	Opened Records	Tutorial Accesses
Initial Time 1st	11 seconds	9 seconds	2	1	
2nd	22 seconds		0		
	Returns to first 2 hits	1 minute 13 seconds			See Table 18, row 1
3rd(rev) Search	19 seconds	37 seconds	4		
4th search	12 seconds	9 seconds	313		
5th Search	9 seconds	60 seconds 5 minutes 31 seconds	15	2	See Table 18, row 2
6th Search	10 seconds	8 seconds	155		See Table 18, row 3
7th Search	17 seconds	0 seconds	0		See Table 18, row 4
8th Search	1 minute 57 sec	1 minute	1	1	
9th search	26 seconds	1 minute 45 seconds 1 minute 36 seconds	56	2	
10th search	1 minute 26 sec	1 minute 30 seconds	56		
11th Search	2 seconds	3 minutes 13 seconds	55	2	

Note. The number of hits she received and the number of records she examined are also reported.

What type of experiences did participants have with the tutorial?

Betsey accessed the tutorial four times during her problem solving activity. She focused on reading the Indexes, but she did not spent much time on the pages as shown in Table 18. In her first access to the tutorial she read the Main, the Evaluate, and the Number Indexes, but she did not spend much time on the pages. Upon her return to the

database, she instituted three revised searches, utilizing new terms and devoting a significant amount of time to reviewing results (Appendix E, E.1 Table 4). For example, following her third search she spent over six minutes looking at some records and the full text of a few articles. Still, this search produced only 15 hits and it led her back to the tutorial. At this point she stayed within the Number and Main Indexes, although she did not devote much time to reading the pages. Her next search attempt included new search terms, but yielded over 150 items and she failed to review many of the results before returning to the tutorial. She again focused on the Main and Number Indexes, but spent a less than eight seconds on either page.

When her subsequent search, that included new terms, yielded no results, she again accessed the tutorial one final time. During her last encounter with the tutorial she discovered the Indexes contained hyperlinks to additional pages and this led her to read the Meditate example. Upon her return to the search screen, Betsey employed the same search terms used in her previous search, but selected three additional databases and she received one result. Following this search, Betsey eliminated one of her keywords and obtained 56 items. Betsey spent nearly four minutes examining some of the records and viewing the full text of this results set. She also incorporated an additional database, Research Starters, to this search and then limited her results to Education Research Complete.

This search yielded 55 hits and she spent over three minutes reviewing the re Betsey used the tutorial for tips on how to improve her search as well as a source of information about the database. For example, she stated “I’m not really happy with the number of results I got so I’m going to go to Number.” At one point she experienced

Table 18

Betsey's Time in Seconds in the Tutorial

Cycle	Main	Number			Relevance				Evaluation				Strategy			
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	15(2)	23								19							
2nd	19	11															
3rd	5	7															
4th		16	16														

Note. Includes her number of accesses to the tutorial components.

difficulty locating the full text of an article. This led her back to the tutorial and after reviewing the Main Index she said "There's nothing on what to do if the article isn't here." Although she read the Evaluation as well as the Number Index, she focused on the latter component of the tutorial accessing it four times during her problem solving activity. She also incorporated some of its suggestions including using new keywords and databases in her revised searches.

How did the tutorial affect outcome of the problem solving activity?

Although she did not appear to gain many database search skills from the tutorial other than an awareness of the ability to change databases (Table 16), her search strategies changed following access to the tutorial. For example, after reviewing the Number Index she focused on examining her results. "I'm going to go back and look at more results for immigration of ells. How many results do I have, I have one two." In her revised searches she experimented with various keywords and phrases in her search string including "culture of ELLs" "immigration of students" and "immigration of students" AND "language". She returned to the Number Index twice and in each of her subsequent searches she changed the terms in the search. In one of her search attempts she spelled out ELLs rather than searching on the acronym. For example, she utilized the terms "sociocultural aspects" and later modified the search to "sociocultural aspects" AND "English language learners." Following her discovery of the Meditate example she also altered her search strategy. The learning objective for this tactic included selecting databases, choosing keywords, broadening the search, and using subject terms. After reading the tactic example, Betsey utilized the same keywords but omitted "learners." The tactic's biggest impact on Betsey's search though was on the use of databases.

During her review of the tactic she exclaimed "Ohhh I can choose my databases. I did not know this option was here. This is really great!" She expanded her databases to include Teachers Reference Center, Education Research Complete, and Primary Search,. The selection of additional sources coupled with the incorporation of new search terms, "sociocultural and "English learners" led to more relevant hits from her previous efforts as well as a more manageable results set 56 compared to 155.

Post-search interview

In Betsey's post-search interview she expressed satisfaction with her results noting "I have the articles I want to use right here." She summarized her strategy in the problem solving activity as focusing on using different keywords to improve the relevance of her results. The main obstacles she experienced during her problem solving centered on identifying the most appropriate terms for the search.

Betsey highlighted the tutorial's value in teaching her about Ebsco and locating additional sources. She remarked "I didn't know that there were that many more journals. So even when I clicked on more of those, I got more results too. That was awesome and I wouldn't have known that without the tutorial." Betsey suggested the problem solving activity and especially the tutorial, simplified her research process. "I thought it would be really hard to research I was just thinking it's going to take so much to read all that stuff but it wasn't." Betsey stated she did not have any difficulties with the think aloud protocol admitting "When I research, I do that already, but it's usually like I'm hungry and I need to go do something."

Summary

Betsey made dramatic gains in scores from her pre-tutorial to post-tutorial

searches (Appendix G, Tables 4a and 4b). The average scores for her first two searches ranked very low in relevance, the ability to answer the problem, and the quality of the response for her results (Table 19). On the other hand, the scores for her final search were all in the above average range for these categories. Betsey also spent a significant more time devising her search strategies and reviewing results following access to the tutorial for most of her searches (Table 17). She also examined seven records after her encounter with the tutorial.

Table 19

Betsey's Pre-Tutorial Search Scores

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant	1				
Authoritative		2			
Answered Problem	1				
Quality of Response	1				

Betsey's initial search strategy did not yield many results due her use of an acronym for "English language learners." Utilizing this phrase in an advanced search with "immigration" would have yielded a significant number of relevant hits.

Kathy

Kathy was an experienced searcher in her mid-thirties. The extent of her database skills are outlined in Table 20 and it reveals her knowledge of Boolean logic, Ebsco's databases, truncation, the advanced search feature, applying limits, and the importance of reviewing results. She appeared especially familiar with the Ebsco databases. Her topic centered on the impact of moving from a one dimensional discussion board in a higher education environment to a two or three dimensional discussion board on adult learners.

What search techniques did participants demonstrate in their initial search?

Kathy noted she was looking for information on adult education, multimedia, and distance education. She utilized Ebsco's advanced search page with Boolean operators to link "adult ed" (truncated) AND "multimedia" AND "distance." She explained her efforts to select only scholarly peer reviewed material stemmed from her graduate student status noting "that is all that is acceptable." In addition, she limited the publication dates of her results to the last ten years. She chose all publication types as well as all databases pointing out "I have learned with at least adult education a lot of things exist in databases other than just the generic education ones. I like to cast a wider net first and then narrow down." She spent nearly three minutes devising her initial search strategy. This search yielded 32 hits. Upon reviewing her results for two and a half minutes, she observed "at this stage I am just looking for keywords really." She said many of her hits were relevant and suggested she wanted to maintain the list. Table 21 highlights the significant amount of time Kathy spent devising search strategy and reviewing the search results from her initial search.

Table 20

Search Strategies Kathy Demonstrated in Her Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial	1		1	1	1	1	1
Post-tutorial	1		5	5	2	2	4

Note. Includes the number of instances of search strategies.

Table 21

Time Kathy Spent Devising Search Strategies and Reviewing Results

Search	Devise Strategy	Review Results	Number of Hits	Opened Records	Tutorial Accesses
Initial Search	2 minutes 37 seconds	1 minute 45 seconds	32	1	See Table 22, row 1
2nd Search	1 minute 50 seconds	41 seconds	77,011	1	
3rd Search	63 seconds	14 seconds	34,547		
4th Search	2 minutes 39 seconds	1 minute 20 seconds	42,370		
5th Search	36 sec	52 seconds	829		
6th search	30 sec	45 seconds	627		
7th Search	43 seconds	43 seconds	47		

Note. The number of hits she received and the records she examined are also reported.

What type of experiences participants have with the tutorial?

Although Kathy only accessed the tutorial once during her problem solving activity, she made a thorough review of the tool. She looked at the Main, Number, and Evaluate Indexes and also spent nearly two minutes reading the Jolt tactic example**.** These accesses are outlined in Table 22**.** Despite her comprehensive examination of the tutorial, she focused on the Evaluation Index. She accessed it three times and read the Jolt tactic twice. Following her review of the tutorial she described her new search strategy that centered on the Jolt tactic. "I got this idea of adding keywords to my search to get either expand or [a] more focused search. So I'm going to head over to this one in there. Well I hadn't thought about, okay I hadn't thought about educational psychology. I hadn't thought about delivery systems. So I'm going to add delivery systems here."

Kathy utilized the tutorial primarily as a one shot learning tool. Still, her attention to the tutorial's content during her review of the tool, facilitated her ability to incorporate its suggestions into her revised search strategies without having to revisit the tool for

Table 22

Kathy's Time in Seconds in the Tutorial

Cycle	Main	Number			Relevance				Evaluation			Strategy			
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1	38(2)	39								32(3)		85(2)					

Note. Includes the number of accesses to the tutorial components.

clarification or additional searching tips.

How did the tutorial affect outcome of search?

Table 20 suggests that Kathy did not gain any search techniques from the tutorial. However, Kathy's search was affected by her access to the Evaluate Index's Jolt tactic that aimed to help users improve search outcomes by evaluating search results. The Jolt tactic suggested readers move out of conventional thought patterns to view the search in an unconventional way. The example highlighted the use of subject terms from relevant articles to improve search results. It also discussed the importance of keywords, phrase searching as well as Boolean operators. Kathy spent nearly two minutes devising the search strategy for her first revised search. In this instance, Kathy employed the Boolean OR operator with keywords she obtained from relevant articles. After reviewing the record of one of her hits she remarked "I hadn't thought about delivery systems. So I'm going to add delivery systems here" Her search using all Ebsco databases for "Adult ed*" AND "Multimedia" AND "Distance" OR "Delivery systems" received over 77,000 hits. Kathy devoted about one minute reviewing these hits before opting to remove databases to narrow her results. "With a list this big the next step that I would do is head over to my databases and takes a look at some of the databases that are pulling because some of these are not going to be education related."

However, Kathy inadvertently selected rather than removed databases. When this effort yielded another large results set, she again focused on her choice of databases. "So maybe we'll put in not medical. Go back to these databases and see. I'm keeping most of the soft science stuff unless its computer science." Her revised search utilized the same keywords, with the new database selection. This search attempt also produced an

excessive number of hits and led Kathy to limit to academic audiences with the keywords "higher ed*. Kathy spent about a half minute devising strategy to further narrow her results this included using the NOT operator to eliminate topics that were not relevant such as "test*" and "assess*". When this attempt produced over 600 hits, she focused on the search limits available from Ebsco's thesaurus selecting "higher education", "distance education," "education technology," "online courses," as well as "universities and colleges." This final search reduced her number of hits from 627 to 47 (Appendix E, E.1 Table 5).

Post-search interview

In her post-search interview Kathy stated the tutorial taught her about incorporating additional terms in her search. According to Kathy, "I had logged out completely and just kept a list of the keywords I liked. I hadn't thought about adding it on to expand my search." She said the tutorial would be especially beneficial to freshmen especially after they received face to face instruction. Kathy remarked "This is almost like the next step, which I like." She described the obstacles she encountered in her problem solving as identifying relevant search terms. Kathy stated "The biggest stumbling block in researching is identifying appropriate keywords particularly "trying to figure out what terms you need in order to get the information you are looking at. If you already know about your topic it is a lot easier. Learning how to navigate can be challenging and can be time consuming." Kathy expressed some difficulty with the think aloud protocol and she stated it was "hard to keep remembering" to explain her strategies. "I just assumed I was going to do this and …"

Summary

Although the Jolt tactic expanded Kathy's result's set, many of the hits in her final search were not relevant. Despite the appropriateness of Kathy's keywords and the time she spent devising her initial search strategy (Table 21) her inclusion of the all Ebsco database option returned many irrelevant results. In addition, in her final efforts, the incorrect placement of the OR operator in the search string yielded many false hits. Her last search results ratings in all categories except authoritativeness were lower than her initial search (Appendix G, Tables 5a and 5b).

However, Kathy did search more efficiently following access to the tutorial. Table 21 reveals she decreased the time she spent in devising search strategies and reviewing results from her initial search to her final search.

The keywords Kathy utilized in her initial search were relevant, but her use of Ebsco's all database option remained too broad and yielded a large result set. Using her initial search terms, "adult ed* "multimedia," and "distance" with the default database, Education Research Complete, and Eric offers a significant number of relevant materials.

Mary

Mary was in her mid-thirties and appeared comfortable in the search environment. However, her familiarity with searching affected her think aloud, she made short comments during her problem solving that frequently did not provide detailed explanations of her thoughts. Her topic centered on theories of reading neurobiological.

What search techniques did participants demonstrate in their initial search?

For her initial search Mary expanded the default database to include PsycInfo before performing a basic search on neurobiological (Table 23). She obtained over

13,000 hits. Mary reviewed a few titles and performed another search using the phrase "neurobiological define". Her last pre-tutorial search was "neurobiological theories of reading" and she obtained over 1000 hits. She spent less than a minute time devising search strategies for the first three searches she performed prior to accessing the tutorial. However, she did review the results for relevancy and she also examined a record as Table 24 illustrates.

Table 23

Search Strategies Mary Demonstrated in Her Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial					1		
Post-tutorial	4				1		

Note. Includes the number of instances of search strategies.

What type of experiences participants have with the tutorial?

Mary focused on the Indexes and she avoided reading any tactic examples (Table 25). Her first foray into the tutorial centered on the Strategy Index that contained descriptions of the Break, Regulate and Skip tactics. Following her initial review of the

Table 24

Time Mary Spent Devising Search Strategies and Reviewing Results

Search	Devise Strategy	Review Results	Number of Hits	Open Records	Tutorial Accesses
Initial Time	35 seconds	66 seconds	13,119	1	
2nd Search	8 seconds	36 seconds	9		
3rd Search	7 seconds	0 seconds			See Table 25, row 1
4th Search		56 seconds	1035	1	
5th Search	17 seconds	2 seconds	2947		See Table 25, row2
6th Search	45 seconds	38 seconds	1	1	See Table 25, row 3
7th Search	15 seconds	61 seconds	2297	1	
8th Search	22 seconds	46 seconds	5		
9th Search	31 seconds	56 seconds	125		
10th Search	20 seconds	7 seconds	45225		
11th Search	5 seconds	34 seconds	1		
12th Search	13 seconds	2 minutes 22 seconds	125	4	
13th Search	36 seconds	51 seconds	81	1	
14th Search	20 seconds	1 minute 15 seconds	844	1	
15th Search	23 seconds	65 seconds	194	1	
16th Search	12 seconds	70 seconds	90	1	
17th Search	7 seconds	7 seconds	39,896		
18th Search	24 seconds	19 seconds	2046		
19th Search	8 seconds	48 seconds	55		
20th Search	17 sec	67 seconds	9533	1	
21th Search	19 seconds	9 seconds	6343		
22nd Search	12 seconds	34 seconds	809		

Note. The number of hits she received and the number of records she examined are also reported.

tutorial, Mary instigated two new searches using new keywords (Appendix E, E.1 Table 6).

After one of her revised searches "neurobiological theories of reading" yielded nearly 3000 hits, she returned to the tutorial and viewed the Number Index noting "I've raised to the limit maybe the number." Her next search attempt was "theories of reading neuro cognitive" and it only produced one result that she dismissed as not relevant. At this point she accessed the Relevance Index twice. This page advised readers to identify search goals, recognize than unproductive search and instigate a new approach and consider the appearance of any clues that may affect your interpretation of the question. Following Mary's last review of the tutorial, she conducted 16 revised searches. Although she typically did not spend much time devising search strategy, she did devote attention to her results by reviewing titles and examining some records.

Mary appeared to use the tutorial to obtain ideas for search strategies rather than database search techniques see Table 24. She looked at the tutorial for tips on how to reduce or expand her search results as well as ideas for improving the relevance of her results. She examined three of the Indexes and typically devoted about thirty seconds to each page. Although she accessed the Main Index, it was most often used as an avenue to the other components of the tutorial.

How did the tutorial affect outcome of the problem solving activity?

Although Mary did not spend much time in the tutorial (Table 25) and she did not read any of the tactic examples, she often changed her search strategy after viewing the Indexes. For instance, her first foray into the tutorial centered on the Strategy Index's

Table 25

Mary's Time in Seconds in the Tutorial

Cycle	Main	Number				Relevance				Evaluation				Strategy			
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	13(2)													33			
2nd	6	27															
3rd	10					51(2)											

Note. Includes the number of accesses to the tutorial components:

Break, Regulate and Skip tactics. These strategies urged readers to change search habits, focus on thought processes and the structure of the search, as well as to adopt a different perspective on the search. In revising her search she remarked "I am going to try something I haven't thought about." To this end, she included the term "models" in her search string. That search yielded nearly 3000 results and prompted her to review the Number Index. This portion of the tutorial offered ideas on analyzing the search strategy, instigating a new search behavior and identifying relevant keywords as well as search fields. Mary revised her search utilizing different search terms that she appeared to obtain from relevant records (Table 24). Her search string was "theories of reading neurocognitive" and obtained one hit. The lack of search results led Mary to the Relevance Index. This component of the tutorial urged readers to identify search goals, instigate new approaches, and look for clues to improve the interpretation of the search.

In her return to the search screen she stated "I'm just typing in theories of reading instead of specifying each." This search yield nearly 3000 hits and prompted Mary to revise her strategy including "phonological processing" in the search string. She appeared happy with the five results commenting "Okay great. These seem interesting." At this point she opted to search for models of reading. In her subsequent search efforts she experimented with various combinations of theoretical models of reading incorporating in "maotts." Following these searches, Mary adopted a new search strategy that centered on locating articles from prominent authors on her topic. In subsequent searches she also reviewed records for theorist names and relevant keywords that she employed in new queries such as "Shaywitz," "Lyon," "Standovich" and "cognitive." In addition to

incorporating new search terms, Mary changed her databases substituting Eric for PsycInfo to focus on educational materials. Her final search yielded over 800 items.

Post-search interview

In her post-search interview, Mary stated she was satisfied with her search results noting she received her goal of ten as well as "a few more." Still, she said the tutorial "slowed her down" since she was very familiar with the computer. Mary emphasized "I search often and I am on the computer daily. I search for any and everything." She identified obstacles to the problem solving activity as "I guess is trying to find those keywords. That's the main thing, finding which words will actually get the meat of what you need." She said she did not have any difficulty with the think aloud protocol "Well to be honest, no because I always talk to myself anyway."

Summary

A comparison of the ratings between Mary's searches before and after exposure to the tutorial showed no improvement as all categories ranked below average (Appendix G, Tables 6a and 6b). However, some of her searches, she conducted 19 in total, did yield above average results especially after she changed her databases to focus on educational materials. In addition, as Table 24 reveals she did spend a significant amount of time reviewing her results as well as examining records during her problem solving activity. Although Mary did not appear to gain many database search techniques from the tutorial as Table 23 illustrates, the focus of her topic improved during the problem solving activity particularly with the development of new search strategies as well as the selection of new databases.

Mary's search suffered from a lack of topic development. This led her to

experiment throughout her problem solving activity utilizing various terms and strategies without any consistency in her search concepts. Her most relevant results appeared with the phrase "theoretical models of reading" and especially after she changed her databases to include Eric rather than PsycInfo.

Still, Mary's search results would have improved by combining elements of her most successful search strategies. Using the terms "neurobiological" AND "theor* or model" AND "reading" with Eric, Education Research Complete, and PsycInfo provides a manageable number of relevant hits.

Daemon

Daemon was a full-time student in his mid-twenties. His identified his topic as the learning theories of Jean Piaget.

What search techniques did participants demonstrate in their initial search?

In his initial search he utilized the advanced search mode as well as Boolean operators with the keywords "Jean pieget" and "learning theories" (Table 26). He did not change the default database Academic Search Premier, but he did select scholarly peer reviewed materials. Despite his misspelling of "piaget," the system returned the appropriate results and he narrowed this hit list using the subject thesaurus term "cognitive development" and received 88 hits. After viewing some titles Daemon declared the hits were too broad and he observed the need to use "more search terms more specific." As Table 27 reveals, Daemon spent a mere 13 seconds reviewing the results from his initial search.

Table 26

Search Strategies Daemon Demonstrated in His Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial			2	2		1	
Post-tutorial	3		9	9	1	3	3

Note. Includes the number of instances of search strategies.

Table 27

Time Daemon Spent Devising Search Strategies and Reviewing Results

Search	Devise Strategy	Review Results	Number of Hits	Opened Records	Tutorial Accesses
Initial Time	33 seconds	13 seconds	32		
2nd Search	32 seconds	10 seconds	88		See Table 28, row 1
3rd Search	45 seconds	11 seconds	436		
4th Search	6 seconds	55 seconds	39		See Table 28, row 2
5thSearch	28 seconds	30 seconds	76		
6thSearch	10 seconds	43 seconds	61		
7th Search	20 seconds	7 seconds	494		See Table 28, row 3
8th Search	37 seconds	32 seconds	13		
9th Search	11 seconds	2 minutes 31 seconds	15	1	
10th Search	28 seconds	11 seconds	5		
11th Search	8 seconds	2 minutes 5 seconds 2 minutes 17 seconds	425	1	See Table 28, Row 4
12th Search	10 seconds	1 minute 33 seconds	27		

Note. The number of hits he received and the number of records he examined are also reported.

What type of experiences participants had with the tutorial such as use of tutorial?

Daemon accessed the tutorial in four separate instances during his problem solving activity and he viewed all of the Indexes (Table 28). In his first encounter with the tutorial he examined the Main, Relevance, and Number Indexes and two tactic examples including the Create and Notice pages. He revised his search following his initial review of the tutorial incorporating a new keyword as well as selecting additional databases. The search "Jean piaget AND Cognitive development AND theor* yielded 436 hits led him to narrow the results utilizing Ebsco's Subject Thesaurus term "piaget theory" (Appendix E, E.1 Table 7). Dwaine reviewed some of these 39 hits for nearly a minute before stating "It's so broad now." In his second access to the tutorial he focused on the Strategy Index, but he did not view any of the tactic examples. Upon returning to the search screen he experimented with various terms. Following his third revised search that yielded nearly 500 hits, he returned to the tutorial. His third access to the tutorial led him to the Strategy and Evaluate Indexes. In his subsequent searches, he devoted more time to reviewing results. In this instance he spent nearly five minutes examining some of the titles and reviewing two records. Still, a search that yielded over four hundred hits prompted him to revisit the tutorial. His final access to the tutorial centered on the Evaluate Index, although he spent merely 13 seconds reviewing the page. Daemon's last search incorporated terms he obtained from reviewing relevant records such as "developmental psychology and "introduction." He noted "This is probably the best search terms I used so far."

Daemon appeared to use the tutorial as a reference source for database search techniques to improve his results. Although he surfed the tutorial examining all of the

Table 28

Daemon's Time in Seconds in the Tutorial

Cycle	Main	Number			Relevance				Evaluation				Strategy			
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	17(3)	26(2)			38	25(2)			6								
2nd	4													25			
3rd	6													23			
										20							
4th										13							

Note. Includes the number of accesses to the tutorial components.

Indexes and two of the tactic examples, the information he gleaned from the tool, supported his problem solving activity. He said that he had previous instruction in research skills at the University since he was taking three classes this semester. Daemon stated the tutorial helped trigger his prior "knowledge" that he received from library skills training classes.

How did the tutorial affect outcome of search?

. Table 26 lists the various database techniques Daemon used in his searches following exposure to the tutorial. In his first review of the tutorial Daemon examined the Notice tactic example as well as the Number Index. These sources highlight the importance of utilizing appropriate databases to enhance the relevance of the results. In his first revised search he expanded his database selection to include Education Research Complete, ERIC, Primary Research, PsycArticles, and PsycInfo. Daemon also read the Create tactic example and it underscored the value of selecting relevant keywords, using subject terms, evaluating results, truncating words, limiting to peer reviewed articles, and using the NOT operator to exclude unrelated materials. His revised search focused on the tactic's suggestion to incorporate relevant keywords as well as the benefits of truncating search terms. This search "Jean Piaget" AND "cognitive development" AND theor* yielded over 400 results. However, by selecting the subject "Piagetian theory" he limited his hits to 39.

Daemon referred back to the tutorial several times during the problem solving activity and changed his strategy accordingly. For example, after reviewing the Break, Regulate, and Skip tactics described on the Strategy Index he remarked "I'm going to clear out these search terms and try something new." His subsequent search included the

terms “Piagetian theory” AND “overview.” After he incorporated “cognitive” into his search string he commented “I’m starting to get articles I can use, some are ebooks, some are them overview of a lot of the psychological theories.” Daemon’s revised strategies focused on selecting appropriate keywords and especially reviewing the search results. For example, he noted “I’m going to take out overview cause that is not the term to use. “In his subsequent search omitted “overview “but added “education” and “teach*.” His dissatisfaction with the results led him to state “I’m going back to the tutorial cause I’m not getting much results.” Following his review of the Strategy, Main, and Evaluate Indexes, he seemingly adopted the latter’s Wander tactic’s advice “to look at the sources” and he subsequently examined the subject terms of relevant articles for more “specific terms.” During his think aloud component of the search Daemon explained “Developmental psychology, I’m using that subject terms of articles I find useful. I am going to use it to search.” After reviewing another article and incorporating a term into his revised search he stated “Introduction was a good word to use.” This strategy ultimately yielded him a successful search. After his final search he commented “All articles I’m finding right now I would either add them to a folder or write these down so I would have access to them later.”

Post-search interview

In his post-search interview Daemon explained his initial search strategy. “Okay I started using Jean Piaget. I know that [who] he was and I typed in theory. I just kinda typed that in as a search term and I got tons of results. So I kind looked down at the subject source and I found out what other words are being used.” According to Daemon, the obstacles in his problem solving centered on “using the right search terms.” He

explained his goal was to find an overview or introduction of Piaget's basic principles and he suggested once he located the proper term he was able to find more materials. Daemon said that he was satisfied with the results and would "be able to use this for my research topic." He indicated the tutorial helped improve his search activity. "Yeah it was good." However, he admitted he knew a lot of the techniques, but reading it "kinda like hit me. I know I should do that."

Daemon expressed difficulty with the think aloud protocol. "It's not like me. I'm always thinking constantly thinking, but thinking out loud I'm not."

Summary

In Daemon's initial search he revealed his knowledge of database search techniques especially in using the advanced search mode and limiting to peer-reviewed materials. In the post-tutorial phase of the activity, Daemon demonstrated awareness of Ebsco's educational databases, the value of truncating, and the importance of locating terms from relevant records. He also made improvements in the rating of his search scores from his first to his last search in every category (Appendix G, Tables 7a and 7b). In addition, following exposure to the tutorial he increased the amount of time he spent reviewing results (Table 27). For example, a comparison of his time spent reviewing results from his first search to his last search was 13 seconds to 1 minute 33 seconds.

The tutorial had a positive impact on Daemon's problem solving activity. Although his initial topic was broad, exposure to the tutorial helped Daemon narrow his search using terms from relevant records. In addition, the tutorial triggered Daemon's previous knowledge and that fostered his ability to conduct a more focused search by truncating terms and using keywords from relevant records.

One strategy that would have helped Daemon reduce the number of his searches combined features of his most successful efforts with a subject search. In this instance "jean piaget" AND SU "developmental psychology or cognitive learning theor*" AND "synopsis or overview or introduction" with education databases, ebooks, and PsycInfo yields a small number of relevant results.

Shelly

Shelly was the oldest participant in the study. She admitted she was nervous and seemed uncomfortable in the search environment. Shelly described her topic as the difference between extrinsic and intrinsic motivation for students as it applies to elementary students and their ability to navigate to the different curriculum goals of the elementary years, especially 5^{th} or 6^{th} grade.

What search techniques did participants demonstrate in their initial search?

Shelly performed a basic search in Academic Search Premier using the phrase "extrinsic vs intrinsic motivation in elementary students." Although she did not receive any hits, Ebsco reverted to smart text searching that yielded 4912 results. Upon reviewing a few of these titles, she noted there were "way too many results" and "it doesn't deal with elementary it deals with college and it goes into I've seen a lot of stuff dealing with schools in Turkey and schools in Korean or China." At this point, Shelley narrowed the result's publication dates to 2010 to the present (Table 29). Although the number of her hits decreased to 967, she said they still had the college theme (Table 30). She attempted to limit by geography but was unable to locate a category for the United States in the results display.

Table 29

Search Strategies Shelly Demonstrated in Her Searches

Search	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Utilize Advance Search	Change Databases	Apply Limits	Truncate
Pre-tutorial						1	
Post-tutorial		7	7	7		2	

Note. Includes the number of instances of search strategies.

Table 30

Time Shelly Spent Devising Search Strategies and Reviewing Results

	Devise Strategy	Review Results	Number of Hits	Opened Records	Tutorial Accesses
Initial Time	34 seconds	30 seconds	4912		
2nd Search	10 seconds	36 seconds	967		See Table 31, row 1
3rd Search	49 seconds	17 seconds + 2 minutes and 28 seconds	36		
4th Search	20 seconds	0 seconds	0		
5th Search	2 minutes 20 seconds	0 seconds	0		See Table 31, row 2
6th Search	10 seconds	12 seconds	2		
7th Search	15 seconds	1 minutes 36 seconds	9	1	See Table 31, row 3
8th Search	22 seconds	0 seconds	0		
9th Search	26 seconds	1 minute 52 seconds	4	1	See Table 31, row 4
10th Search	36 seconds	0 seconds	351		
11th Search	47 seconds	3 minutes 42 seconds	33	2	

Note. The number of hits she received and the number of records she examined are also reported.

What type of experiences did participants have with the tutorial?

Shelly spent a lot of time in the tutorial, nearly nine minutes and this is documented in Table 31. She read all of the Indexes and the majority of the tactic examples. Following her review of the tutorial she often summarized the main learning outcomes in the search component of her think aloud. For example, in her first encounter with the tutorial she read the Main and Relevance Indexes as well as the Catch and Think tactic examples. At this point she stated "So what I'm finding that possibly I'm not putting things in. I maybe am using too big a phrase as opposed to a couple of words in quotes." In her subsequent revised search, she spent more time devising search strategy and reviewing results than she had in her initial search. When these searches yielded little or no results, she returned to the tutorial. In revisiting the tutorial and especially the Relevance Index and Notice example, she said "One of the biggest things I believe is talking about specific using subject terms." At this point she conducted two searches utilizing subject terms and Boolean operators to incorporate terms and synonyms (Table 32). She spent nearly two minutes reviewing the results from a relevant record (Table 30). Still, this search yielded her only nine results and prompted her to return to the tutorial. Her third access to the tool focused on the Number Index and the Change tactic example. In her third review of the tutorial she studied the Number Index and the Change example tactic. In her revised search, she included a new search term, but received no hits. A subsequent search that also contained a new keyword, yielded few results, but Shelly carefully reviewed these results for nearly two minutes.

Table 31

Shelly's Time in Seconds in the Tutorial

Cycle	Main	Number				Relevance				Evaluation				Strategy			
		Index	Meditate	Change	Create	Index	Think	Catch	Notice	Index	Wander	Jolt	Identify	Index	Break	Regulate	Skip
1st	16					30(3)	47	45									
2nd						25			54								
3rd	2	30		27													
4th	15(2)									67(3)	36	86		10(2)	23		

Note. Includes the number of accesses to the tutorial components.

Table 32

Shelly's Searches and the Number of Hits

Extrinsic vs intrinsic motivation in elementary students-4912
Update with present to 2010,- 967
'intrinsic' 'extrinsic' 'motivation'-36
'intrinsic' 'extrinsic' 'motivation' 'elementary'-0
Grades (SU) AND intrinsic or extrinsic AND 'motivation' elementary-0
Elementary education (SU) AND intrinsic or extrinsic AND 'motivation' elementary -2
Elementary education (SU) AND intrinsic or extrinsic AND 'motivation'-9
Elementary education (SU) AND intrinsic or extrinsic AND 'grading-0
Elementary education (SU) AND intrinsic or extrinsic AND grades-4
Elementary education (SU) AND intrinsic or extrinsic OR grades and motivation-1309
SAME SEARCH WITH dates 2009-2011)-351
Elementary education (SU) AND intrinsic or extrinsic OR grades and motivation (checks US)-33

Her final examination of the tutorial centered on the Evaluate and Strategy Indexes' tactics and she read the Jolt, Break, and Wander examples. Shelly's last search employed some of her earlier terms but they were linked with the Boolean OR not the AND operator. This strategy helped expand her search results and she obtained over 1300 hits. However, Shelly was able to reduce this results set using Ebsco's date and geography features to 33 items. Shelly examined all of the tutorial's Indexes and many of the tactic examples for search strategies as well as to obtain database search techniques to improve outcomes. Many of the strategies and database techniques described in the Index pages and tactic examples appeared in Shelly's revised searches.

How did the tutorial affect outcome of the problem solving activity?

Table 29 reveals that Shelly demonstrated use of search techniques presented in the tutorial in her searches. During Shelly's first review of the tutorial she focused on the Think and the Catch tactics described on the Relevance Index. The Think tactic admonished users to identify search goals and the Catch tactic highlighted the need to

recognize an unproductive search and instigate a new approach. Shelly applied some of these tactics in her revised search by focusing on the selection of keywords. This search "intrinsic" "extrinsic" "motivation" yielded 36 results. After reviewing the hits Shelly incorporated the term "elementary." The lack of results from this search led Shelly back to her initial 36 hits. She commented "I like these, I hadn't seen these before."

Still, she stated some of the results were not relevant. To this end, she returned to the tutorial and accessed the Relevance Index and the Notice tactic example that urged readers to consider any clues that may affect the interpretation of the question or how to answer it. The tactic examples for Think, Catch, and Notice also contained database search techniques that described the use of Boolean operators, subject terms, and synonyms. At this point Shelly instituted an advanced search using subject terms as well as the AND and OR Boolean operators. The search strategy included "Grades" (SU) AND "intrinsic or extrinsic" AND "motivation" elementary yielded no results. Shelly continued to experiment with various keywords including substituting "elementary education" as a subject term for "grades" and deleting "elementary." Still, this search yielded only 9 results leading her to read the Number Index and the Change tactic example. This tactic helped Shelly identify an additional search term "grades" but her revised effort failed to return many results. Still, she scanned some records to identify relevant keywords. "Ah here is some more words reinforcement, personal choice."

In her final review of the tutorial she accessed the Wander, Jolt, and Break tactic examples. These pages provided similar database search instruction to the tactics accessed earlier, with one exception. The Wander tactic example contained information on the Ebsco's cited references and related records features. Shelly did not include these

advanced features in her subsequent searches, but she did maintain the advanced search mode with the Boolean operators in her search incorporating additional terms. For example, one of her last search strategies centered on “elementary education” (SU) AND “intrinsic or extrinsic” OR “grades and motivation.” In Shelly’s final search she narrowed the publication dates to 2009 to the present and limited to materials published in the United States. This search yielded 33 results that she indicated contained material applicable to her topic.

Post-search interview

In her post-search interview Shelly emphasized her lack of experience in searching that she said stemmed from her extended hiatus from college to graduate school. “When I went to college we had electric typewriters and you went into the library and found microfiche and microform. So it was a very different way of searching. It was pretty one dimensional. Now learning this it’s certainly not one dimensional. It’s a matter of remembering where I was and how to navigate it and getting back again.” She believed the tutorial was helpful. “Before I did that I did not understand about this stuff, putting that in and the subject terms and refining the field.

To this end, she identified the obstacles in her problem solving activities to learning the new search techniques in the digital era. “For me it’s learning this because I’ve never been exposed to this kind of stuff. “

She also stated she located relevant material in the activity and found the tutorial helpful. “Yeah before I did not understand about this stuff, putting that in and the subject terms and refining the field. I didn’t understand that so I wasn’t doing it. So now when I go home this will be an easier thing for me to do.”

Summary

Although Shelly demonstrated some knowledge of search techniques in her initial search, she gained more skills following exposure to the tutorial. In addition, as Table 30 illustrates, Shelly searched more efficiently following access to the tutorial spending less time devising search strategies and more time reviewing results. For example, she typically spent two minutes reviewing results and less than a minute devising search strategies. She also examined records in the post-tutorial phase of the problem solving activity. In addition, she utilized the advanced search mode with Boolean AND and OR operators in her subsequent searches. For example, her search "elementary education" and "intrinsic" or "extrinsic or grades" and "motivation" received above average ratings for all categories. The tutorial also underscored the value of synonyms to Shelly and she experimented with various search terms throughout her activity. Comparisons between the scores for Shelly's first search and last search reveal increases from average to above average in all categories (Appendix G, Tables 8a and 8b).

Shelly's use of Boolean logic improved the relevancy of her search results. Still, her results list were typically too large or too small. This remained especially true for her last search that employed the Boolean operator OR with grades and motivation. The narrowness of her topic required attention to subject terms as well as databases searched to return relevant results. In this case, searching SU "intrinsic motivation or extrinsic motivation or motivation in education" AND SU "elementary or school children" yields a significant number of relevant results.

Overall

Research question 1: What search techniques did participants demonstrate in their initial search?

In their initial search seven out of eight participants demonstrated some familiarity with advanced search techniques. These included tactics to narrow search results such as setting publication dates, limiting to peer-reviewed materials, or utilizing the subject thesaurus and location features of the results page. Likewise, during their first search more than half of the participants had an awareness of the importance of selecting appropriate databases to enhance their search results. Advanced search techniques remain especially important in maximizing the power of database searching by allowing users to include additional databases, limit to specific fields, incorporate various versions of a term, narrow to specific dates and article types, as well as employ Boolean logic.

Databases. The majority of participants recognized the role of the databases in returning material relevant to their topic. However, only three individuals expanded the default database, Academic Search Premier, to include additional sources. This may have stemmed from a lack of knowledge on how to choose databases in Ebsco. For example, at the onset of her problem solving activity, Betsey remarked "I've never used Ebsco."

On the other hand, Dwaine and Mary immediately selected additional databases to include in their search. Kathy utilized the "all database" option in Academic Search Premier explaining "with adult education a lot of things exist in databases other than just the generic education ones." She indicated a desire to "cast a wider net first and then narrow down." Lesley opted not to choose any databases for the initial search "because I just wanted to see what I can get."

Still, for the initial search activity less than half of the participants appeared knowledgeable of the availability of Ebsco's advanced search mode, the value of truncating, and the benefits of Boolean operators. The majority of participants performed a basic search in the Ebsco database with a few keywords or a phrase rather than access the advanced search page. Their query length was short and ranged from two to five terms.

Research question 2: What general attributes were common among participants in their use of the tutorial?

The majority (n=7) of the participants referred back to the tutorial during the problem solving session, but the number of and motive for their accesses varied. For example, Dwaine read the tutorial's Change Example and opted to follow the Example's advice to utilize the keywords from a relevant record to improve search results.

However, Dwaine's inability to locate keywords in the record led him back to the Change Example for additional information. Moreover, Amy referred back to the tutorial's Change Example to locate tips on reducing the number of her hits and also to filter her results.

On the other hand, Betsey, Lesley, Mary, and Shelly accessed various components of the tutorial numerous times during the activity. They scanned it to obtain ideas for improving their search results. Betsey also wanted information on how to access the full text of an article if it wasn't available from the record. Likewise, Daemon sought tips from the tutorial on improving his search results. After reviewing one of his revised searches he stated "I'm going to go back to the tutorial cause I'm not getting much

results." On the other hand, Kathy only read the tutorial once. She utilized it as a one shot learning tool.

Popularity of components. The Number Index remained the most popular component of the tutorial followed by the Evaluation and Relevance Indexes. The popularity of these pages mirrored the problems participants encountered in their problem solving activity. All participants sought methods to broaden or narrow their search results due to too many or too few hits. For example, Lesley received only four results in her initial search while Amy obtained over 18,000 hits for this component of the activity.

In addition, participants (n=4) sought information on how to evaluate their results to improve subsequent searches. Kathy applied the Evaluation Indexes' Jolt tactic to "get a more focused search." In this instance, she examined a relevant record in her initial search results to obtain keywords to include in her revised search. Shelly also read this tactic example and in her revised search she incorporated Boolean operators and substituted synonyms for the terms used in her initial search.

Some participants expressed concern about the relevance of their results that did not support their topic and this led several (n=3) to the Relevance Index. Shelly stated the articles don't "deal with elementary it deals with college and it also goes into I've seen a lot of stuff dealing with schools in Turkey and schools in Korea or China." Moreover, Lesley noted "the third one is about parenting which I'm not sure would be really relevant."

Participants accessed the Main Index frequently as Tables 8, 12, 15, 18, 22, 25, 28, and 31 reflect, but only as an avenue to the tutorial's other pages. Only Dwaine, Lesley, and Kathy spent more than thirty seconds reading the Main Index initially.

Participants spent the least amount of time in the Strategy Index, although it was reviewed by Daemon, Mary and Shelly.

Those participants that demonstrated knowledge of advanced search skills in their initial search and appeared comfortable in the search environment including, Daemon, Betsey, and Mary relied on the Indexes, rather than the examples, for ideas to improve their search. The Indexes focused on descriptions of the metacognitive idea tactics, rather than applying specific database search strategies.

Table 33 illustrates Daemon, used all of the Indexes and Mary reviewed three out of four. Betsey accessed the Main Index in four separate instances. These individuals appeared very confident in their search abilities throughout their problem solving activities and they did not express uncertainty or nervousness while searching. Daemon said he was a full time student and had received library instruction in several of his classes early in the semester.

On the other hand, Table 33 illustrates Amy, Dwaine, and Lesley focused on the Number Index in their use of the tutorial. While Kathy examined the Number Index as well, she only accessed it once compared to the Evaluation Index that she viewed in three separate instances. Table 33 reveals that Shelly, like Daemon, examined all of the Indexes. However, unlike Daemon, Shelly did not appear confident in her search abilities, but both participants utilized the tutorial to gather ideas to improve the outcome of their problem solving activities.

Table 33

Total Number of Seconds Participants Spent Reading Index Pages

Name	Main	Relevance	Number	Evaluation	Strategy
Amy	9, (1)		34, (2)		
Betsey	49, (4)		57, (4)	19, (1)	
Daemon	27, (5)	25, (2)	26, (2)	33, (2)	48, (2)
Dwaine	38, (1)		69, (1)		
Kathy	38, (2)		39	32, (3)	
Lesley	31, (1)		111,(5)		
Mary	29, (3)	51, (2)	27, (1)		33, (1)
Shelly	33, (4)	45, (4)	30, (1)	67, (3)	10, (2)

Note. Includes the number of accesses to the Indexes.

Participants also spent a significant amount of time in the Jolt example. This example was available under the Evaluation Index and it aimed at helping users evaluate search results to improve outcomes. Although it was accessed by only two out of seven participants, these individuals devoted a significant amount of time reading the example. For instance, Kathy spent nearly half of her total time in the tutorial reviewing the Jolt Example and Shelly devoted a minute and a half to the page. An identical number of individuals accessed the Notice Example, but they did not spend much time on the page.

Three of the tactic examples were not used at all. Two appeared under the Strategy Index and included the Regulate and Skip examples. In addition, the Identify example that was available from the Evaluation Index was not accessed. The lack of use of these tactics may have stemmed from their location. Two were listed on the Strategy Index, the last Index on the Main Index page. Moreover, the Identify Example was listed at the bottom of the Evaluation Index page. Participants sought to access links as quickly as possible and often did not click on links at the bottom of the pages.

Only Shelly, moved around the tutorial reviewing every Index and nearly all of the examples and this is illustrated in Table 31. Daemon, utilized all of the Indexes as well but he only viewed two tactic examples.

The remaining participants, six out of eight stayed within the Number or the Evaluation Indexes. Within these indexes, with the exception of Lesley, individuals accessed only one tactic example or none.

Time in tutorial. The amount of time individuals spent reading the Index pages and the tactic examples varied (Tables 8, 12, 15, 18, 22, 25, 28, and 31). Participants' number of accesses to these tutorial components also ranged during the problem solving activities as these Tables reveal.

Research question 3: What search techniques did participants demonstrate in their final searches?

The tutorial and database search skills. All participants gained search skills following exposure to the tutorial. Table 34 lists the search techniques performed by participants during the activity in their revised searches and the number of times they performed these strategies. The list does not reflect all of the techniques participants employed during the activity, but only those that were not displayed in their initial search. Participants may have had familiarity with a technique, but failed to demonstrate it during their initial search.

Table 34

Search Strategies Participants Demonstrated in Their Revised Searches

Name	Locate Terms from Relevant Articles	Use Subject Terms	Employ Boolean Operators	Change Search Terms	Change Databases	Apply Limits	Truncate
Amy		1	2	2			
Lesley	1		7	7	1	4	5
Daemon	3			8	1		3
Shelly		7	7	4			
Mary	4			16			
Kathy				3			
Dwaine	1		2	2			
Betsey				6	2	1	

Note. Includes the number of instances of search strategies.

All of the database techniques presented in the tactic examples were reflected in at least one of the participant's revised searches with one exception. Although Shelly read the Wander Example that contained information on the cited reference feature, she failed to utilize this strategy in her revised search. However, several techniques were presented in tactics that were not accessed by any of the participants. These included the related records feature and option to specify methodology. Their lack of use suggests participants were unaware of these more advanced database features.

Attention to keywords. The most common strategy participants gleaned from the tutorial centered on utilizing more relevant keywords. In this instance all participants experimented with employing various concepts for their search terms (Appendix C). Lesley explained "I'm thinking of keywords." Kathy stated "Distance or delivery is kind of what I'm looking for." Daemon said "I am going to take out overview cause that is not the term to use." Following another unsuccessful search he noted "I'm going to clear out these search terms and try something new."

Attention to keywords also led to participants' use of the Boolean operators. Kathy was the only participant to use the NOT operator to exclude items from her results set. On the other hand, Shelly incorporated the OR operator within a field to expand the number of relevant results.

The think aloud protocol revealed many participants focused on the age of their students in selecting keywords for their search (Appendix C). As Kathy remarked "Age is definitely one I would look at. I want to make sure these are all adults." Lesley explained her use of the term kindergarten "that is my age group." Likewise Shelly sought studies involving elementary students. Similarly Amy utilized 'first grade student' in her search terms. In these instances participants sought to increase the relevancy of their results.

Some participants incorporated subject terms from relevant records in their new strategy. However, subject terms were typically used as keywords and not as a fielded search. Daemon obtained search terms for a revised search from the subject source terms in a catalog record he deemed relevant. He stated he was "culling subject terms for more specific terms. I'm using subject terms of articles I find useful."

Lack of subject term usage. Only Shelly and Amy conducted searches utilizing the subject terms field in their revised strategy. The lack of results led Amy to change her search to an all text field. Shelly also had difficulty using the subject search in Ebsco. This is surprising considering the emphasis of the tutorial on incorporating subject terms to improve search results. Nearly all of the tactic examples pointed to the use of subject terms to improve relevance. Participants focus on keywords in their revised searches may have stemmed from time constraints. Many of the tactics listed on the Index pages point to the simple changes that impact searches such as the importance of selecting

appropriate keywords. Using a variety of keywords in a search remained an easy strategy to improve results.

The tutorial also highlighted the importance of databases to participants (Appendix C). The tutorial provided Betsey information on the variety of databases available from Ebsco. “Oh I did not know this option was here!” Although, the majority of participants remained familiar with education related sources, the tutorial reminded participants of databases’ significance in returning relevant results. Lesley stated “I know Education Research Complete is one I think I can use.” She admitted “I could use to separate articles written about education from articles about patients, subjects, and psychological studies.” Likewise following a review of the Create tactic’s suggestion to identify relevant databases, Daemon selected the eBook collection, Education Research Complete, Eric, Primary Search, PsycArticles, and PsycInfo. Mary also changed her databases in the middle of her problem solving activity replacing Eric with PsycInfo.

Truncation was another strategy participants gleaned from the tutorial. Several participants truncated terms in their revised searches. Although Lesley said she learned this strategy from an instructional class, the tutorial may have triggered her knowledge of its value in information search.

The use of quotation marks represented a further technique demonstrated in the tutorial and was included participants’ revised searches. However, individuals inadvertently determined the quotation mark placed in the tutorial to designate keywords was a search technique. In this instance they placed quotation marks around their keywords to enhance their search results. As Shelly said “So now I am instead of putting in a phrase, I’m going to put in a few works using quote marks.”

Review for relevant keywords. The tutorial also increased participants' tendencies to review records for relevant keywords (Appendix C). Dwaine insisted "The tutorial told me to look at keywords in an article that looked relevant and use that in my search. I am going to use one of these keywords as subject since this article is relevant." Kathy explained "I got about Jolt which is this idea of adding keywords to my search to either expand or more focused search. So I'm going to head over to this one and look at their keywords and hopefully there is one in there." Similarly Shelly examined the record of a relevant article for more keywords. "Ah here is some more words reinforcement, personal choice." While reviewing a relevant search result, Daemon stated "I want to go back and see what the search terms are here."

Change in search modes. In addition, the tutorial impacted participants' use of search modes in their revised searches. Following access to the tutorial, four out of five participants went from Ebsco's basic to the advanced search mode in their revised searches using the Boolean AND operator. The remaining three participants had utilized this search technique in their initial search. Although the mechanics for accessing the advanced search mode was not described in the tutorial, the tactic examples contained screen captures of this feature and the accompanying text described the advantages of using Boolean operators.

Research question 4: How did the tutorial affect the outcome of the problem solving activity?

Access to the tutorial did not affect the number of revised searches participants performed. Figure 1 in Appendix H represents a scatter plot of the total time participants spent in the tutorial compared to their number of revised searches. The illustration

revealed a random scatter of points. This distribution indicates there was no relationship between the total time in the tutorial and the number of revised searches individuals performed.

There was an association between the amount of time participants spent in the tutorial and their examination of records (Appendix H, Figure 2). The line of points runs from the upper left to the lower right that indicates the relationship between the two variables was negative. This distribution suggests the more time participants spent in the tutorial the less records they examined for some individuals. Still, there was no association between the number of records viewed and participants' final search scores. A scatter plot of those variables illustrated a random scatter of points. There was a relationship between the time spent in the tutorial and the time devoted to revising search strategy (Appendix H, Figure 3). The line of points in this instance clustered from the lower left to the upper right that indicated a positive relationship for some individuals. The distribution reveals participants spent more time revising their search strategy as their time in the tutorial increased.

This affected the outcome of their searches indirectly. As Appendix H, Figures 4-6 illustrate there was a negative distribution between the time spent devising search strategy and half of the participants' scores for relevance and the ability to answer the problem, and the quality of their last search. The scatter plot in these diagrams reveal a cluster of points from the upper left to the lower right indicating an inverse relationship.

Exposure to the tutorial appeared to have an inverse effect on the amount of time participants devoted to reviewing results (Appendix H, Figure 7). This scatter plot displays a cluster line from the upper left to the lower right that indicates an inverse or

negative relationship. Participants spent less time reviewing results as their time in the tutorial increased. There was also a negative relationship between time spent in reviewing records and some (n=4) of participants' scores for relevance, ability to answer the problem, and the quality of their last search. This is displayed in Appendix H, Figures 8-10.

As Table 35 displays the time participants spent devising search strategies and reviewing results before and after exposure to the tutorial varied. In addition, the number of records participants examined in the post-tutorial phase of the activity ranged from zero to 12 and was tied to the number of seconds spent in the tutorial, but not on participants scores on their final searches. The more time in the tutorial, the less records participants opened.

Table 35

Total Seconds Participants Spent Devising Search Strategy and Reviewing Results

Name	Devising Search Strategy Initial	Reviewing Results Initial	Initial Records Viewed	Devising Search Strategy Post	Reviewing Results Post	Records Viewed Post
Amy	19	25	0	85	572	7
Betsey	33	82	1	298	989	7
Daemon	55	23	0	213	695	2
Dwaine	87	56	0	55	101	1
Kathy	157	105	1	441	275	1
Lesley	18	57	0	192	255	0
Mary	43	102	1	353	887	12
Shelly	34	30	0	375	643	4

Note. Zero records reviewed indicates only titles were reviewed and no records were opened.

Tutorial accesses and final search scores. Scatter plots displaying participants' total minutes in the tutorial with their final search ratings for relevance, authoritativeness, ability to answer the problem, or quality of the last search reveal a random scatter of

points. This distribution suggests there was no relationship between time spent in tutorial and participants' final search scores. However, for half of the participants, increased accesses to the tutorial led to higher scores for the relevance and quality of the last search as well as its ability to answer the question. In these instances, the line of cluster points ran from the lower left to the upper right (Appendix H, Figures 11-13).

Most of the participants, six out of eight, made gains in their search scores following access to the tutorial. Figures 14 to 19 available in Appendix H illustrate the improvements in search scores for relevance, the ability to answer the question, and the quality of the response for all but Mary and Kathy. There were gains made for the authoritativeness of the responses between the first search and the last search as well for most participants. These bar charts reveal the impact of the tutorial on participants' final search scores. The relevance of the results for Daemon, Dwaine, and Shelly increased from 3.0 to 4.0 respectively. Amy and Betsey gains for results' relevance were more pronounced increasing from 2.0 and 1.0 respectively to 4.0 for their final searches. In addition, Lesley increased the relevance of her results from 2.0 to 3. Similar gains were witnessed by the participants in the other score categories.

Mary's lack of search improvement following access to the tutorial could be attributed to the 19 revised searches she performed. Figures 20 through 22 in Appendix H reveal an inverse relationship between the number of revised searches and the relevance of the last search, the ability to answer the problem as well as the quality of the last search for some participants. The distribution depicts a line that runs from the upper left to the lower right for the three participants that suggests the relationship between the two variables was negative.

Search obstacles and participants' satisfaction level

Obstacles

Broad results. Several obstacles were revealed from the think aloud problem solving activities (Appendix C). For example, all of participants obtained results that were too broad and required efforts to narrow the search during their problem solving activities. Dwaine described his use of the subjects "to narrow down my actual search." Likewise, Kathy eliminated databases that were not education related to narrow down her number of hits. Shelly focused on peer reviewed journals, setting dates and limiting the geography to the United States. Narrowing down individuals' search results was not limited to an excessive number of hits. In one of her revised searches, Lesley obtained 24 results which she admitted was better than previous searches, but she explained, "I would probably want to narrow this down."

Number of results. Only Mary and Shelly had a clear idea of how many items they wanted. These participants aimed to meet the requirements for their paper and that was ten articles. Other participants neglected to note how many materials they wanted. Amy suggested she "didn't know." Overall participants sought fewer result, rather than large numbers of hits. Kathy considered 32 items "pretty good." When Dwaine's revised search yielded 20 results, he noted "that's much closer." Shelly indicated her 32 results were "much less to look through." However, Lesley indicated a desire to narrow down the 24 results she received from searching "mindfulness" AND "teach" AND "class". Still, Lesley noted she wanted "A good one, quality not quantity. I don't know what she is requiring for the project." Many reached a point in the search where they were satisfied with the number and the quality of their results. After placing a number of

articles in his folder, Daemon stated “I mean I would probably stop here cause I’ve got enough.” Likewise, Betsey said “Okay, I pretty much have all which is exciting.”

Time. Time represented another concern for participants in searching (Appendix C). Lesley pointed out “I got fewer hits with this. I still have 170 I mean I would be willing to go through these but I know it’s not very efficient.” Shelly remarked “There is quite a few here that I would actually take the time and really look at.” Betsey remained surprised at how quickly she was able to locate relevant materials for her assignment. “I was just thinking it’s going to take so much to research all that stuff, but it really wasn’t.”

Uncertainty and errors. Participants’ feelings of uncertainty and errors were revealed in the activities (Appendix C). Several participants appeared to lack confidence in their search strategies and results. Comments such as “I have got 32 results which is pretty good I think,” “I am going to stop here I think,” and I don’t understand” suggest participants remained uneasy in the search environment. Shelly readily admitted she did not have search experience describing herself as a “novice.” Dwaine concluded “The obstacles were my own in that I didn’t know exactly what was good to solicit in the results I wanted.”

Spelling errors and other mistakes were also common during the problem solving activities particularly during the initial search and with the use of surnames. In one instance Kathy inadvertently selected numerous medical related databases she had intended to delete. Moreover, Lesley limited to materials published in recent years, but forgot to update her date selection. Likewise, Dwaine and Mary misspelled surnames in their searches.

Other problems participants encountered stemmed from their lack of awareness of

search techniques and the peculiarities of databases. For example, several participants utilized quotation marks around keywords since this was illustrated in the tutorial. However, in that instance quotations highlighted keywords employed in the search. Quotations were not used as a search technique in the tutorial. Ebsco fails to recognize quotation marks unless they are preceded by field names. In addition, Dwaine appeared confused about the difference between locating keywords and subject headings in a record as well as how to obtain Boolean operators. “The tutorial talked about using keywords from the article that was relevant, but I don’t see a page that has keywords just subjects.” In his post-activity interview he noted “I did notice that in the screen shot of the tutorial it used AND it didn’t tell you how to get those.” Moreover, Betsey assumed Ebsco provided full text availability for all of the materials in the database. “Oh, the whole thing isn’t here. There’s nothing on what to do if the article isn’t here.”

The biggest error though centered on participants' use of keywords without Boolean operators. In this case Ebsco treated the words as a phrase and reverted to smart text searching that yielded large result sets that were typically not relevant to the topic. The note “Your initial search did not yield any results” preceded the results set.

Think aloud. The majority of participants (n=5) did not view the think aloud protocol as an hindrance to their information seeking in the activity (Appendix C). Mary stated “Well to be honest no cause I always talk to myself anyway.” Betsey said “When I research, I do that already, but it’s usually like I’m hungry I need to go do something” about it.” Shelly noted “I do remember when most times where I’ve been.”

Some participants experienced problems with the think aloud protocol. Dwaine admitted it was difficult to explain his actions while searching. He said “It’s not like me.

I'm always thinking but thinking out loud I'm not." Lesley suggested "I wasn't sure if I was to be talking to you to no one." Kathy noted it was hard to keep remembering to explain her actions. Still, these participants sought to emphasize an awareness of their search strategies. Lesley pointed out "I do think about what I'm doing most of the time. I'm not just putting things in and seeing what happens."

Satisfaction. All participants expressed satisfaction with the results obtained from their problem solving activities (Appendix C). Betsey was especially pleased pointing out "I have all the articles I want to use right there. I'm just grateful I did this today because I got all my articles." Mary appeared pleased as well suggesting "after some time you find exactly what you need. Well I aimed to get ten. The big ones I really wanted and I got those ten plus a few more." Daemon concluded "I will be able to use this for my research." Lesley suggested she found "A few really good ones I feel like, gems." Shelly admitted she was seeing things she hadn't seen in earlier searches. "I've seen ones that I have not seen." Kathy's comments related to her initial search results. "I really like the first ones and second ones. I want to save these."

Additional issues revealed in the post search interview and during the think aloud

Research skills. The problem solving activity highlighted the importance of research skills to participants (Appendix C). In their post activity interview participants discussed the value of research skills. According to Daemon "Research is something that you kind of need. It's a skill almost. Having tutorials and being taught a specific strategy is very helpful especially at the graduate level." Lesley pointed to a recent instructional session she had attended noting "It was the first time anyone had even mentioned to me things like using an asterisk." Shelly observed "for me it's learning this because I've

never been exposed to this kind of stuff. For me it's learning how to do this. When I went to college it was one dimensional find of stuff in card catalogs." Kathy believed the "biggest stumbling block is trying to figure out what terms you need to search for in order to get the information you are looking at."

Librarians and libraries. The problem solving activity also increased participants' appreciation of librarians and libraries (Appendix C). Daemon noted he had learned a lot of strategies from the university's librarians who provided instruction in several of his classes early in the semester. Kathy applauded the value of librarians to graduate students. She described them as the experts in searching library databases and admitted she sought advice from them following a search. "I always try to search on my on first and if I get too much or too little or not what I am looking for I always go to a librarian. Here's what I am looking for do you have any suggestions, can you help me get any closer." Lesley discussed her recent experience with an instructional class at the university that was very helpful because before I would go through page after page of articles trying to find ones." Mary expressed her use of libraries explaining "I wouldn't go into Google automatically I would go into the library and find those scholarly databases first."

Summary

Participants benefited from the problem solving activity and especially its intervention on two levels. First, the tutorial highlighted individuals' awareness of the metacognition concept and encouraged them to apply planning, reflecting, and evaluating strategies in their searches to improve outcomes. The idea tactics provided participants suggestions aimed at changing their thought processes to improve search strategies and

results. Many participants seemingly adopted these ideas especially as Bates intended them be used including when searchers were "stumped." Second, the provision of various search techniques in the tactic example pages served as a how to guide for applying advanced search skills. Seven out of eight participants demonstrated some gains in database search techniques following exposure to the tactic examples. In two instances participants noted the tactic examples triggered their prior knowledge that they employed in subsequent searches. Consequently the tutorial remained an effective intervention for supporting education graduate students' search in digital libraries.

V. DISCUSSION

The present study contributes to the research on information problem solving by illustrating the effectiveness of a metacognitive scaffold for improving search outcomes, especially in digital libraries. Land and Greene (2000) wrote that system and domain knowledge remained especially important for information seeking in open ended environments. However, they also reported that metacognitive knowledge compensated for individuals' lack of familiarity with various subjects and technologies during information search. In the present study, a tutorial centered on idea tactics promoted metacognitive strategies as well as database techniques to enhance individuals' awareness of their information seeking skills and improve search outcomes. Following an initial search on a topic, participants selected tutorial tactics aimed at enhancing their search outcomes. The number of subsequent searches participants performed in the post-tutorial phase of the activity varied, but did not affect the scores for relevance of their final search results. All individuals demonstrated some advanced search techniques following exposure to the tutorial that improved their search outcomes. Participants also appeared to apply the metacognitive strategies promoted by the intervention in their problem solving and that often produced more relevant search results.

Metacognitive interventions.

The present study offers evidence of the effectiveness of a metacognitive based tutorial in enhancing participants' problem solving in digital libraries and especially in

improving their search outcomes. Hill and Hannafin (1997) suggested individuals that lacked metacognitive knowledge experienced difficulties in identifying information needs, evaluating resources, and revising strategies. Consequently research on metacognitive interventions highlights their effectiveness in building metacognitive skills. Many of the interventions in the present study centered on encouraging participants to plan, monitor, and regulate their cognition.

Bates idea tactics

Bates (1979) described the purpose of her idea tactics as "generating new ideas or solutions" to problems in information searching (p. 280). She suggested these ideas may help "professional information specialists" in searching print or electronic databases and should be used primarily for situations when the searcher is "stumped" (p. 280). The author advocated utilizing these tactics at the "beginning of a search" or "when ordinary means have failed" (p. 280). The article described the tactics as part of a "facilitation model of searching" directed at improving search efficiency and effectiveness (p. 280).

Bates (1979) arranged her tactics into two groups including: idea generation and pattern breaking. She listed idea generation tactics as Think, Meditate, and Wander. She viewed pattern breaking tactics as Catch, Break, Notice, Jolt, Change, and Skip. In pattern breaking, the author suggested some of the tactics were designed to "break patterns of thought" while others aimed to change aspects of a search to alter individuals' perspectives (p. 289).

Idea tactics tutorial. On the other hand, in the present study the tactics were grouped to facilitate participants' efforts to devise solutions to problems users encounter during information search such as the relevance of the results and the number of hits.

Two additional categories, evaluation and strategy, provided tactics to promote evaluating and strategizing participants' problem solving.

Three tactics utilized in the tutorial did not appear on Bates' list. These tactics were based on metacognitive strategies including: Create, Identify, and Regulate. In the present study two of these tactics examples, Regulate and Identify, were not accessed during participants' problem solving activities. This may have stemmed from their location in the tutorial. Identify appeared as the last link in the Evaluation Index. Regulate and Skip, the latter comprised another tactic example not accessed during the study, was available in the Strategy Index, the last index on the Main Index page. Participants sought those tactics examples most easily accessible and these were typically from the Relevance and Number Indexes, links that appeared at the top of the Main Index page. Participants' failure to access the Regulate, Skip, and Identify tactics did not necessarily impact their search outcomes since the tactics contained material that was often described in other tactics such as Boolean operators and subject terms.

In the present study, the idea tactics were utilized by students with some search experience, not professional information specialists. Participants performed an initial search on a topic and utilized the idea tactics for strategies aimed at improving their search outcomes. Amy and Dwaine focused on the Change Tactic and the Number Index to obtain ideas to revise their search strategies and improve their results. Kathy visited the tutorial once and read two Indexes and one tactic during her problem solving. The remaining four participants referred back to the tutorial throughout their problem solving reviewing Indexes or tactic examples for various strategies to enhance their search outcomes.

Idea generation and mental pattern breaking. The present study confirmed Bates' suggestions that the tactics helped "generate new ideas or solutions to problems" in searching and that their use is applicable in print and online databases (p. 280). Following access to the tactics all participants experimented with keywords, and some (n=3) changed databases, (n=4) accessed Boolean operators, and (n=2) utilized subject terms. Lesley and Daemon also truncated terms and some participants (n=4) examined relevant records for keywords to include in subsequent searches.

The idea tactics fostered as Bates maintained (p. 281) "mental pattern breaking" for the eight participants. This was especially apparent during Mary and Betsey's problem solving activities and it improved their search outcomes. For instance, Mary began her search using PsychInfo and the default Academic Search Premier Database. Following numerous unsuccessful searches she viewed the tutorial's Relevance Index. This page contained two of Bates' "mental pattern breaking" tactics including Catch and Notice. Bates described these tactics as of the "introspective sort" suggesting the individual "introspects and analyzes the problem" and "breaks accustoms ways of thinking" (p. 281).

Upon revising her search, Mary changed her search terms several times using variations on "models of reading" and also switched from PsychInfo to Eric. At this point, the relevance of some of her subsequent search results increased (Appendix E, Table 6). She also opted to seek "four key writers that subscribe to that [neurobiological] "theory" rather than search on "neurobiological." Likewise, Betsey demonstrated "mental pattern breaking" following her review of the tutorial. Her initial searches centered on the acronym E-L-Ls. After reading the tutorial's Evaluate and Number Indexes' "mental

pattern breaking" tactics such as Jolt and Change, Betsey spelled out her search terms initially to "English language learners" and latter using "English learners" and received more relevant search results (Appendix G, Table 4a and 4b). Bates distinguished the Change, Focus, and Skip mental pattern breaking tactics from the others. According to the author these strategies facilitated "arbitrary" changes to provide a "different perspective to solve the problem (p. 281). In this instance Betsey's use of the Change tactic may have facilitated her use of new search terms rather than the acronym.

In addition, Bates promoted the idea tactics as facilitating "idea generation" in searches and this too was revealed in the present study. Following access to the Relevance and Number Indexes' "idea generation's" Think and Meditate tactics, Daemon experimented with various keywords in his search. For example in subsequent searches he substituted "Piagetian theory" for "jean piaget" and "cognitive learning theory" for "cognitive development." The tutorial also helped him hone his search strategy to obtain summaries of Jean Piaget's work through the inclusion of terms such as "overview" and "introduction." Kathy's problem solving also offered evidence of the "idea generation" role of the tactics. Following a review of the tutorial that included reading the Evaluate and Relevance Indexes that contained the "idea generation's" Think and Wander tactics, Kathy examined a record to locate additional terms (or ideas) to incorporate in her revised search. In addition, Shelly demonstrated idea generation following review of the Wander tactic in her inclusion of the Boolean OR operator to add "grades or motivation" to her search.

Database search strategies. The inclusion of database search strategies with the idea tactics provided users additional techniques designed to enhance search results.

Participants that focused on these examples, such as Dwaine and Lesley, demonstrated "idea generation," "mental pattern breaking," as well as improved database search techniques during their problem solving activities. Dwaine read the Change tactic example and this enabled him to break his "mental pattern" by adopting the advanced search mode and new search terms in his revised strategy. In his subsequent search, Dwaine employed the Boolean AND operator to link "classroom observation" with "technology integration" and he reduced his number of hits from over 13,000 to 20. After he consulted the tutorial again he changed "technology integration" to "technology assessment" and obtained his desired results. Likewise, Amy employed suggestions presented in the Change tactic as well following her review of the example. It led her to use new keywords and conduct a subject search. Amy's first search centered on keywords "reading activities first grade" and it yielded only one result. Following two reviews of the tutorial and the "mental pattern breaking" Change tactic she conducted an advanced search and changed her search terms from "early literacy reading activities for a first grade student" to "first grade student" in subject field and "reading activities" that produced no hits. This led her to change "first grade student" to an all text field that yielded 22 hits and these contained some relevant results. Neither Amy nor Dwaine demonstrated knowledge of the advanced search mode or subject terms in their initial search. Both of these participants improved their final search scores for relevancy, the ability to answer the question, and the quality of the response from their initial search (Appendix G, Tables 1 and 2).

Overcoming obstacles. Participants used the idea tactics as Bates (1979) suggested to overcome obstacles they encountered during their problem solving. Taylor

(1962) identified problems users encountered in search environment that he attributed to the organization of the system, the question and its complexity, as well as the individual's "state of mind" (p. 394). He believed the latter was especially important since it could affect users' abilities to receive the appropriate information (p. 394). Other authors emphasized the role of users' in facilitating the search process. Kuhlthau (1993) described stages users' progress through in their information seeking that included feelings of uncertainty. According to the author, "information seeking was a process of construction where users progress from uncertainty to understanding" (1993, p. 345). This progression was also witnessed during participants' problem solving activities as they obtained relevant materials to support their topic. Following Lesley's search on "mindfulness and early childhood education" and "teach*" and "class" she examined the results and commented "I think this is better." In her post-activity interview she alluded to the importance of understanding to her search. "I want as broad, as many thing to choose from as possible. With this topic, I'm not exactly sure exactly how I feel about it, or how I would use it. I just want to learn about it and see if the things I am interested in are connected in other people's minds."

Likewise, upon reviewing his results, Daemon noted "All right now I'm culling subject terms. I'm finding more specific terms for John Piaget." Moreover, after reading the tutorial Kathy commented "So what I'm finding that possibly I'm not putting things in. I maybe am using too big a phrase as opposed to a couple of words in quotes. I'm going back."

Moreover, the organization of the tutorial using the themes of Relevance, Number, Evaluation, and Strategy was designed to support participants during their

problem solving. These themes represented common search obstacles users experience and therefore facilitated participants' access to tactics designed to enhance outcomes. After an unsuccessful search that yielded one result, Lesley said "so I'm stuck." She returned to the tutorial and read the Number Indexes' Meditate tactic example for additional search ideas. Likewise, Daemon stated "I'm going to go back to the tutorial because I'm not getting many results." At this point he examined the Strategy and Evaluate Indexes.

The most popular tutorial components were the Number and Evaluation Indexes and this may have stemmed from the difficulties participants experienced in their problem solving. Participants accessed information aimed at alleviating search obstacles such as too many or too few results, a common problem for most individuals during the activity. For example as Dwaine noted "I'm going to click on the link for dissatisfied with the number of hits cause 13,000 is too much." Amy noted she obtained "a ton" of results after one of her revised searches.

Participants spent the most time in the Change and Meditate tactic examples located in the Number Index. Participants also sought advice on how to evaluate their search strategies as well as their results. After reviewing the Evaluation Index, Betsey commented "I'm going to go back and look at more results." Kathy also selected the Evaluation Indexes' Jolt tactic example and noted her intention to "add keywords to either expand or [get] a more focused search."

Likewise, participants' behaviors during the present study were in agreement with the information seeking research in their depiction of the obstacles that searchers face as well as the uncertainty they experience in this environment. In her post-search interview

Kathy described a search obstacle as the "lack of consistency in search terms at all ever." For other participants a lack of system knowledge and inefficient search skills produced uncertainty during their problem solving especially at the start of their activity. During her initial search, Betsey pointed to her lack of familiarity with Ebsco. "I've never used Ebsco." On the other hand, Shelly emphasized her inexperience with database searching throughout her problem solving activity and in the post-search interview. During one attempt to revise her search she asked "Now do I change fields?" Moreover, Lesley's comments during her think aloud hint at her uncertainty as well during the activity. "Well it looks like not all of these are from the types of journals that I would want, probably. There are still too many, I think."

Some participants' uncertainty was manifested in nervousness. In her think aloud Shelly commented "The words I'm typing in are extrinsic vs. intrinsic motivation elementary students spelled wrong because I'm nervous."

The findings of the present study remain in agreement with some of the results from Moore's (1995) information problem solving research in identifying problems users experience formulating search strategies. Although the author focused on eleven year old students' information problem solving, the present study shared similar conclusions. Moore observed students were aware of their difficulties in identifying "questions to drive information retrieval" (p. 20). This too was a complaint of some (n=3) of the problem solving participants in the present study. As Lesley commented "It's hard for me to think of sometimes to put my ideas into words. It's hard to choose relevant search terms that get me to go where I want to go without boxing me in." Mary stated "The main thing is finding which words will actually get the meat of what you need." Amy said

"Well, I first typed in a long phrase and came up with hardly anything at all." However, while Moore observed the youngsters experienced difficulties delineating "fragments of information" from concepts to create more focused "information seeking," this was not the case for the graduate students (p. 22). Participants in the present study were typically able develop better strategies to improve their outcomes. After reviewing his results, Daemon stated "Cognitive learning theories, I'm going to add cognitive to the search." When Lesley's search on "mindfulness in young children" proved unsuccessful, she substituted the phrase "early childhood education."

Tutorial enhances search outcomes

A comparison of participants' search results before and after exposure to the tutorial revealed six out of eight individuals ranked higher in the relevance, the authoritativeness, the ability to answer the problem, and the quality of the response in the scores for their final efforts (Appendix F, Tables 1 through 8). Moreover, in subsequent searches following exposure to the tutorial, all students demonstrated some use of database techniques presented in the intervention including: using a variety of search terms, reviewing records for keywords, accessing the advanced search mode, selecting additional databases, and employing subject terms. In addition, participants' comments in their post-search interviews on the tutorial remained favorable. Some individuals, especially Lesley and Daemon, noted it triggered their prior knowledge of search techniques. Other participants such as Kathy, Dwaine, Amy, and Shelly likened the tutorial to a tool and suggested it offered new strategies for searching. Kathy stated it would be especially beneficial to undergraduates. Lesley described it as "having enough information to help without taking too long to get through." Shelly said the knowledge

was especially helpful to her due to her inexperience with searching. She pointed to learning about subject terms and refining fields. According to Shelly "Now when I go home, this [search] will be easier for me."

An analysis of participants' interaction with the tutorial highlighted the value of the tool in improving search outcomes. Scatter plot diagrams in Figures 11, 12, and 13 available in Appendix H, illustrate a parallel relationship between the number of accesses to the tutorial and higher search scores for participants' final search for the relevance, the ability to answer the problem, and the quality of the response in their final search efforts.

Impact of metacognitive scaffolds. The present study confirms previous research on the role of metacognitive scaffolds in improving individuals' problem solving. Wolf, Brush, and Saye (2003) maintained their Information Problem Solving model, by supporting students in task analyses, strategy selection, and self-monitoring, helped individuals overcome their lack of writing experience. Likewise, in the present study, the tutorial, by promoting participants' planning, monitoring, reflecting, and evaluating efforts, served to facilitate individuals' search activities regardless of their subject knowledge or database skills. Dwaine appeared to have scant knowledge of his topic. In his first revised search Dwaine pointed out "What I am really looking for is information on tools used to evaluate technology integration in the classroom and I'm still not finding that." Upon reviewing his results further he stated "Actually here is one." Dwaine opened this record and utilized one of its subject terms, "technology assessment", in a subsequent search. This yielded Dwaine 4 results that he noted were very relevant.

Land and Greene's (2000) research on pre-service teachers' information seeking attributed differences in outcomes to participants' domain, system, and metacognitive

knowledge. Still, in the present study differences existed only for the outcome of participants' initial searches. The tutorial served to minimize differences among participant' skill levels. For example, Kathy and Daemon exhibited system and domain knowledge and it was reflected in the advanced search strategies they utilized in their initial search as well as their initial search scores. On the other hand, Amy, Lesley, Betsey, Shelly, and Dwaine lacked extensive domain and/or system knowledge. Their exposure to the tutorial led them to overcome these deficiencies as their final search scores reflected. Shelly a self-described novice searcher stated "Well I'm finding different things, which is important for the paper." Lesley noted she found "a few really good ones, gems." The tutorial assisted participants' abilities to modify their search behaviors by refining topics, developing new search strategies, assessing results, and performing additional searches.

Present study highlights the value of time management in searching

On the other hand, scatter plot diagrams in the Appendix H, Figures 3, 4, 5, 6, 8, 9, and 10 suggest participants did not benefit from spending an extensive amount of time in the tutorial. The distribution suggests an association between time spent in the tutorial and time spent devising search strategies and reviewing results as well as opening records. However, increased time devoted to analyzing search strategies led to lower scores in the final search for all the categories except authoritativeness.

Participants that spent more time in the tutorial spent more time devising search strategy, less time reviewing records, and also opened fewer records. This may have led to individuals' information overload as it hindered their ability to think coherently and devise effective search strategies based on the available information (Appendix H,

Figures 3, 4, 5, 6, 7, 8, 9, and 10). Effective information problem solving for these eight participants required they balance their attention to devising search strategy, reviewing results, and examining records during search. Time spent devising search strategy was important for identifying relevant search terms and techniques as well as in selecting databases to utilize. In addition, participants needed to review results and examine records to gauge the appropriateness of their strategies as well as to locate search terms from relevant records to incorporate in revised searches. Time remained critical in the problem solving activity and underscored the value of participants' effective use of their metacognition.

In its identification of information overload as a problem with searching digital libraries, the present study confirms previous research on this topic. Hess (1999) used the think aloud protocol to examine a graduate student's cognitive processes while searching in a hypermedia environment. The author concluded information overload characterized her cognition while web searching and it was exacerbated by the individual's lack of system knowledge and inefficient research skills. Although in the problem solving activities participants searched scholarly databases, the volume of material available in these sources coupled with dense content of instructional material in the tutorial as well as the requirements for problem solving can overwhelm individuals in all types of search environments.

Failure to review results. Some of Walraven, Brand-Gruwel and Boshuizen's (2009) conclusions on users lack of efforts in reviewing search results also support the present study. The authors found secondary students searching the web spent scant time evaluating the results, the information or the sources that the researchers attributed to

time restraints, motivation, and convenience and this was verified in the problem solving activities of the present study. The authors also noted students failed to make meaningful comments regarding the relevancy of the results. These "utterances with "undefined criteria" (p. 245) were observed for Mary and Amy in the present study who made comments such as "these are great," "a little bit more" and "umm". Still, some individuals in the present study alluded to the problems with their results in their think aloud. After examining a few titles Kathy stated "I would probably take out the word testing and assessment because that is not what I am interested in." Likewise, Dwaine observed "What I am really looking for is information on tools used to evaluate technology integration in the classroom and I'm still not finding that." Walraven, Brand-Gruwel, and Boshuizen suggested students' outcomes suffered from their failure to review results. However, in the present study, final search scores for most participants ranked in the average to above average range and did not appear to be tied to participants' results review (Appendix G, Tables 1 through 8). The time individuals spent reviewing records varied as did the number of records individuals opened.

Importance of tutorial as a reference tool

The tutorial remained most beneficial to participants when it was utilized briefly for reference purposes rather than as a one shot learning tool. Dwaine and Amy's problem solving activities illustrate this use. Although neither participant spent an excessive amount of time in the tutorial, they adopted its suggestions and referred back to the tool for additional ideas or to clarify information accessed earlier. After re-reading the Change tactic Amy indicated "I am going to change this [field] to subject." Dwaine noted his effort to adopt the tutorial's suggestion to use "keywords from an article that was

relevant." Both individuals obtained better results compared to their initial searches following review of the tutorial and neither participant had to perform an excessive number of revised searches to obtain improved outcomes (Appendix G, Tables 1 and 2). Kathy, on the other hand, employed the tutorial as a one shot learning tool. After her initial search, she examined the tutorial viewing two indexes and one tactic example. She applied the strategies presented in the example in her revised searches. These strategies increased the number of her results, but she did not increase the relevance of her results (Appendix G, Tables 5a and 5b). Revisiting the tutorial may have provided Kathy with tips on methods to reduce her number of hits as well as the relevancy of her results.

Participants that appeared comfortable in the search environment such as Betsey, Mary, Daemon, and Betsey, typically read the Indexes rather than the tactic examples. Their problem solving suggested these individuals utilized the tutorial as a reference source to gather ideas from the tactics to improve search outcomes. The Indexes promoted the use of metacognitive strategies and did not include database search techniques. An examination of their searches (Appendix E, E.1 Tables 4, 6, and 7) illustrate the use of new strategies and keywords during these participants' problem solving. After Mary read the Strategy Index that contained the Skip tactic that urges readers to "explore the topic from a different perspective" she added the term "models" to her search string. Likewise, Daemon's review of this Index led him to incorporate "overview" into his search terms.

However, Lesley and Shelly also moved in and out of the tutorial during their problem solving activity using it as a reference source for search tips and database search techniques as well as metacognitive strategies aimed at improving their results. These

participants obtained more relevant results following access to the tutorial (Appendix G, Tables 3 and 8). Following Lesley's examination of the Number Indexes' Meditate, Change, and Create examples she incorporated Boolean search operators in her search. Shelly's application of the Notice tactic example also led to her use of Boolean operators and to utilizing the subject field.

The value of the tutorial as a reference source during problem solving may stem from the variety of difficulties participants encountered while problem solving that required review of the tutorial for search tips in reducing results, expanding the number of hits, or increasing the relevancy of results. Likewise, the time participants spent in the tutorial that ranged from 6 to 210 seconds suggest individuals scanned the Indexes and the examples to obtain strategies to improve their search results as quickly as possible to resume their problem solving.

A variation in the problem solving skills of the participants suggests the tutorial would be effective as a reference source for some individuals. For example, Tabatabai and Luconi (1998) found differences between problem solving strategies among expert and novice education graduate students. Experts were identified by the number of hours they spent on the web each week. The authors reported experts devoted more time to planning search strategies, setting goals, and reflecting on the task compared to the novices. The latter, the authors reported, overlooked relevant sources and suffered from information overload unlike experts.

The present study found similar differences between those participants with varying levels of search skills such as Daemon and Shelly. Daemon demonstrated his knowledge of advanced search skills in his initial search and he also revealed planning as

well as goal setting during his problem solving activity. When his search returned irrelevant results, Daemon explained "I'm going to start choosing more databases." On the other hand, following Shelly's initial search that yielded nearly 5000 results she appeared overwhelmed and remarked "I have to figure out how to get it down." However, both individuals utilized the tutorial as a reference tool. Both individuals accessed the tool four times during their problem solving activity and made gains in the relevance of their results as well as its ability to answer the question, and the quality of the response from the first to the final search (Appendix G, Tables 7 and 8).

Still, Hill and Hannafin (1997) found system knowledge influenced strategy use and also affected search outcomes. In the present study, participants' system knowledge did not impact individuals' search outcomes. Mary and Kathy seemingly had extensive computer skills that were revealed in their initial searches as was as their comfort level when searching. At the onset of the problem solving activity, Mary selected PsychInfo to support her search on "neurobiological theories of reading." In her post-search interview, she stated she was very familiar with the computer and she searched often. Moreover, Kathy demonstrated advanced search skills during her initial search with her use of Boolean logic, truncation, narrowing tactics, and selection of databases. In this instance, participants' system knowledge did not lead to improved search outcomes. Mary and Kathy's final scores for their search's relevance, the ability to answer the problem, and the quality of the response ranked lower than their initial effort (Appendix G, Tables 5 and 6). This may have stemmed from Kathy's failure to use the tutorial as a reference tool and Mary's lack of access to any of the search tactic examples. These tactic examples provided database search techniques designed to improve outcomes.

Participants' adoption of idea tactic's metacognitive behaviors in problem solving

It was possible to collect evidence of metacognitive changes in participants' search strategies as a result of the tutorial. Mary focused on the Indexes rather than the tactic examples. The Indexes highlighted the importance of metacognitive strategies and especially the use of appropriate keywords, plans, and sources rather than specific database search techniques. After Mary's review of the Relevance Index she used different search terms. For example she changed "theories of reading phonological processing" to "theoretical models of reading." In a later search she utilized Eric rather than PsycInfo. This decreased the number of her results but increased the relevancy, the quality of the response, and the ability to answer the problem for these searches that increased from below average in relevance, ability to answer the problem and quality of the response to average and above average respectively. Moreover, in subsequent searches Mary opted to search for "four key writers that subscribe" to the neurobiological theories of learning (Appendix E, Table 6). These names she obtained from careful review of records in her results.

Betsey's concentration on the Indexes may have influenced her to change her search strategy during her problem solving activity. In this instance, she expanded the number of databases she searched as well as spelled out acronyms in her keywords. For example she substituted "English learners" for "E-L-Ls" and selected additional education related databases such as Teachers Reference Center, Education Research Complete, and Primary Research (Appendix E, Table 4). This search strategy produced a more manageable results set at 56 hits as well as an overall improvement in her search scores that went from below average to average and above average (Appendix G, Tables

4a and 4b). Daemon too preferred the Indexes rather than the tactic examples. He experimented with various keywords throughout his activity and also changed his database selection. For example, he expanded his databases to include Education Research Complete, Eric, Primary Research, PsychArticles, PsychInfo, and ebooks. These sources allowed him to limit his results to "Piagetian theory" utilizing the subject thesaurus and that effort reduced his number of hits from 436 to 39. By experimenting with various search terms for the remainder of the problem solving activity, he located additional relevant material and also gained scores in his search results in the relevance, the authoritativeness, the ability to answer the problem and the quality of the response from his first search to his last (Appendix G, Tables 7a and 7b).

On the other hand, those individuals that implemented strategies described in the tactic examples improved their search outcomes as well. In this instance participants also demonstrated use of database search techniques presented in the examples. For example, Dwaine accessed the Change example tactic and adopted its advice to solicit keywords from relevant records for his revised search. In his subsequent search he included the term "technology assessment" that he located from examining a relevant title. This strategy increased the relevancy of his hits and improved his scores that were above average in all categories (Appendix G, Tables 1a and 1b). According to Dwaine "Out of four results, I would say three of them would be exactly what I am looking for."

Likewise, Amy also applied the Change tactic example's strategies in her revised search and increased the number of hits as well as the relevancy, authoritativeness, ability to answer the problem, and quality of the response. She also demonstrated metacognitive strategies in her evaluation of the final results noting each title's relevancy to her topic.

According to Amy, the articles included a wide variety of materials that would support her topic on reading activities for a first grade student. These included reading for the whole class, incorporating television in reading, peer reading, connecting reading and writing, reading strategies and comprehension, and English language learners.

Lesley's searches improved in relevancy after she accessed the Number Index's Meditate example. This tactic example promoted the use of various keywords, broadening the search and truncating words. Following review of the tutorial, Lesley incorporated numerous terms in her search string and also truncated terms. For example, she substituted "early childhood education" for "young children" and experimented with various terms to capture the instructional aspect of her topic such as "kindergarten" "public school" "class" and "teach." Her revised strategy helped reduce the number of her hits while increasing her scores in all categories for her final search results (Appendix G, Tables 3a and 3b).

Kathy's adoption of the search strategy promoted by the Jolt tactic including, adding keywords to expand the focus and number of results, did not improve her final search results for the relevancy, ability to answer the problem, and quality of the response (Appendix G, Tables 5a and 5b). In this instance Kathy's selection of Ebsco's all database option coupled with her incorrect placement of the Boolean OR operator produced a number of false hits. However, Kathy indicated she gained new search techniques from the tutorial particularly in using the Boolean operators to expand a search with multiple keywords.

Shelly's problem solving activity illustrates the impact of the tactics as well as the search techniques on outcomes. Shelly accessed the tutorial three times examining all of

the Indexes and the majority, nine out of twelve, of tactic examples. She changed her strategy in subsequent searches employing many of the techniques described in the examples. For example, after reviewing the Relevance Indexes' Catch and Notice tactic examples she focused on using subject terms and synonyms in her search. Her review of the Jolt tactic with its emphasis on the Boolean OR operator prompted her to incorporate additional terms in her search (Appendix G, Tables 8a and 8b).

Value of metacognitive scaffolds. The present study confirms previous research on the role of metacognitive scaffolds in improving individuals' problem solving. Wolf, Brush, and Saye (2003) maintained their Information Problem Solving model, by supporting students in task analyses, strategy selection, and self-monitoring, helped individuals overcome their lack of writing experience. Likewise, in the present study, the tutorial, by promoting participants' planning, monitoring, reflecting, and evaluating efforts, served to facilitate individuals' search activities regardless of their subject knowledge or database skills.

In addition, Huttenlock (2007) maintained accesses to the tool appeared to stimulate metacognitive behaviors. This was especially true for the present study. In these instances the tutorial helped individuals that received too many or too few results, as well as irrelevant hits clarify their thought processes and this promoted strategy development. The idea tactics utilized by the participants offered suggestions such as "change, meditate, create, jolt, notice, think, notice, wander, and break" that facilitated problem solving through the generation of new strategies as well as the explanation of database search techniques. After reading the Jolt tactic example Kathy explained "So I got about jolt which is this idea of adding keywords to my search to get either expand or more

focused search. So I'm going to head over to this one "intersection of training and podcasts in adult education and look at their keywords. Well I hadn't thought about educational psychology." Dwaine demonstrated similar use of the tutorial's Change tactic with his review of a relevant record and his incorporation of the term "technology assessment" in his search terms. This provided him a result set that contained three out of four items he believed were "exactly what I was looking for."

Embedded instruction. The findings of the present study are in line with Wopereis, Brand-Gruwel, and Vermetten's (2008) research on the effect of embedded instruction on solving information problems. The authors concluded embedded instruction produced a positive effect on individual's regulation of the IPS process that they attributed to the reflective questions. In the present study, the tutorial offered suggestions that served as reflective questions and prompts to guide participants in seeking new strategies for their problem solving. This remained particularly apparent for the Change tactic, the most popular tactic in the tutorial. The Change tactic urged readers "to instigate a new search behavior, keyword or source or strategy." Upon reading this tactic, many participants such as Dwaine, Amy, and Lesley adopted these suggestions and altered their search behaviors. Dwaine's comment upon reading the tactic remains illustrative of its impact on participants search strategy. "Now I'm going to try to change the wording of my search by using "classroom observation and technology integration." Amy too incorporated the Change tactic's strategies on broadening her revised search that yielded no results. In this instance, she changed her subject search to an all text field and obtained 22 results. On the other hand, Lesley incorporated new keywords in her revised search after reading the Change tactic substituting "early childhood education" for

"young children." This expanded the number of her results that increased from four to 231. It also led her to employ advanced search techniques to narrow her results by specifying dates and peer reviewed materials.

Participants increased awareness of metacognitive abilities while problem solving

The present study shares outcomes similar to Chen and Ge's (2006) findings on the benefits learners received from prompting and expert modeling. In the present study, the tutorial, like the cognitive modeling system in Chen and Ge's research, helped participants trigger their prior knowledge as well as supported them during their problem solving. Both Lesley and Daemon observed the tutorial facilitated their abilities to remember search techniques presented in previous library instructional classes. However, Lesley noted her earlier instruction focused on a "predefined search" but the problem solving allowed her to "do it on my own." According to Daemon "I knew a lot of it. When I was reading it, it kinda like hit me. I know I should do that that way, it just kinda triggered." In addition, one of the participant's comments about the tutorial in the present study remained similar to those voiced by the graduate students in Chen and Ge's research on the helpfulness of the cognitive modeling system in facilitating individuals' thought processes. Lesley described the tutorial as having "enough information to actually help someone thinking."

Participants' think aloud also offered evidence of self-reflecting in their problem solving. Kathy noted "I'll go to the advanced search page. It's easier for me to start here because I know off the bat there is a lot of things I don't want." While explaining her initial search strategy, Kathy remarked "I'm going to go ahead and [select] all publication types for now and all document types. So I will probably eliminate some of these later on.

So the other place that I'm going to go is choose my databases. I have learned with at least adult education a lot of things exist in databases other than just generic education ones." Similarly, Lesley maintained "I know I could probably go into one of those better articles and see what terms they use." Daemon explained his use of Ebsco's folder feature. "I would add it to a folder so I could find it latter." In reviewing her the results of her initial search, Shelly explained her previous difficulties in narrowing the hits. "There is no field I can find or understand or limit it to elementary school."

Mary also demonstrated metacognitive knowledge while outlining her information seeking behavior. "I wouldn't go into Google automatically. I would go into the library and find those scholarly databases first." Dwaine highlighted the importance of citation tracing to his information seeking strategies. "I would want to see what the references are. I would look at specific articles based on citations. One of these is from a book so I have a feeling there would be quite a few citations named."

The present study also found relationships between individuals' use of metacognitive strategies in their information problem solving. For example, in their think aloud protocols Daemon and Amy revealed planning and evaluating search efforts. After reviewing one of his results Daemon explained "I'm looking for more like a biography, more like a concentration of his theories. This is just for instance an elementary teacher's application of John Piaget theories. It's just so, I need to get definitely more specific." To this end, in his revised search he incorporated the term "overview" with "Piagetian theory."

Likewise, upon examining her results, Amy evaluated each title for its relevancy to her topic. She noted one article was "about summer reading. It is not relevant." On the

other hand, she maintained "Which reading lesson instruction characteristics matter for early reading achievement? "was really good. It has reading instruction for early reading." Betsey also reviewed many of her results for relevancy to her topic. She stated "Latino English Language Learners: Bridging achievement and cultural gaps between schools and families" was not relevant since "I'm looking for immigration, not bridging gaps."

The illustration of participants use of metacognitive strategies while problem solving, supports previous research on the topic by Perkin and Salomon (1989), Flavell (1978), Sternberg and Frensch (1989, 1990), and Brown (1977, 1982). These authors maintained individuals use metacognition in problem solving for monitoring, regulating, and coordinating the process. Likewise, Marchionini (1989) highlighted the role of metacognition in information seeking. Marchionini observed metacognition instigated individuals "information need," facilitated the creation of "mental models for systems and domains," and promoted the monitoring of the search's "progress" (p. 14).

Moore (1995) concluded all students in her study demonstrated incidences of metacognitive activity, but she noted differences in the quality of their knowledge as well as the complexity of the strategies they exercised. This also proved true for the graduate students in the present study. All participants employed metacognitive behaviors, but the extent of their use and their effectiveness differed among individuals. For example, Lesley demonstrated planning in her search explaining "I think I'll narrow down by getting peer reviewed journals. I'm not going to get full text yet cause I'm still looking to see what I can get." Likewise, Kathy revealed extensive planning in her initial search with her use of specific keywords, selection of databases and document types, and

specification of publication dates. Similarly, Mary offered evidence of self-reflecting strategies when reviewing an article's relevance. Upon reading the title aloud "Towards a neurobiological model" Mary commented "possibly, I need to check it out."

The present study also supports much of Huttenlock's (2007) findings on the role of a scaffold in facilitating metacognitive strategies during information search. Huttenlock highlighted users' efforts to identify relevant keywords through revised search efforts and this too was observed in participants' problem solving activities. The author also noted all participants, even those in the control group, employed metacognitive strategies during search that she believed stemmed in part from their responses to the information displayed on the search screen. This was revealed in the present study during participants' initial search (pre-tutorial) when individuals demonstrated planning, self-reflecting, and evaluating strategies. For example, in his initial search, Dwaine noted "I'm going to type in classroom observation and choose my databases first." Upon reviewing the results from her first search, Mary observed "Not exactly what I want. I want to find a more specific study of research." In addition, Huttenlock found that the advance organizer that was used differently by participants helped enhance their metacognitive questioning that was more deliberate and focused. Likewise, participants in the present study used the tutorial differently. In this instance, Dwaine, Kathy, and Amy relied on the intervention to improve their basic search strategy that they changed only slightly during their problem solving activity. These participants accessed the tutorial infrequently and largely to clarify information on search techniques. On the other hand, Mary, Shelly, Betsey, Lesley, and Daemon utilized the tutorial as a reference source for search strategies and skills.

Monitoring. Moreover, the present study verified Tabatabai and Shore's (2005) research on the role of monitoring as a characteristic of expert searching. This was illustrated during Mary's problem solving activity. In selecting search terms, Mary, a self-described skilled searcher, noted words she "had previously used."

However, monitoring was observed among novice searchers as well in the present study. During her think aloud Shelly explained "Well I'm finding different things which is important for the paper." Similarly Dwaine noted "Out of these four results I would say three of them would be exactly what I am looking for so I would at this point take those three print them and read them." Moreover, following a search that yielded 170 results, Lesley noted "So I got fewer hits with this."

Education students use of metacognitive skills. In addition, the present study supports previous research on the importance of metacognitive skills in facilitating education students' information seeking. It confirms Hill and Hannafin's (1997) findings on the role of metacognition in promoting students' orientation in the system, but in the present study, disorientation did not affect search outcomes.

For example, Shelly alluded to a lack of orientation in searching during her post-activity interview. "It's a matter of remembering where I was and how to navigate it and getting back there again. I do remember when most times where I've been, it's just a longer haul for me." Still, Shelly's disorientation did not hinder her development of appropriate search strategies for her topic. Her final search scores increased in all categories from her initial effort (Appendix G, Tables 8a and 8b). Lesley suggested the selection of keywords remained especially important in minimizing problems with

orientation in search. “It’s hard to choose relevant search terms that get me where I want to go without boxing me in.”

Importance of metacognition and information literacy instruction. The present study validates enhancing students’ awareness of metacognitive strategies as well as database search techniques in information literacy instructional efforts. These findings suggest that the idea tactics can help searchers of all skill levels improve their outcomes while problem solving in digital libraries. Foremost, the findings support the use of the tactics as a reference tool to enhance search results as needed during problem solving. As Thewall (2004) noted scholars require new skills to search in digital libraries. Blummer, Lohnes and Kenton’s (2009) survey of education graduate students’ research skills pointed to some individuals’ dissatisfaction with the content of their previous library instruction. Some respondents described the instruction as “very basic” and two individuals suggested it was not helpful. Research in the European Union highlights the value of students’ information problem solving skills and especially their metacognitive strategies in planning, monitoring, and self-regulating web and database searching behaviors. Consequently, the present study sought to demonstrate the value of a metacognitive scaffold in improving education graduate students problem solving in digital libraries by increasing their awareness of metacognitive skills.

Findings of the present study’s similarities to information use research

Information and behavior. Theorists highlight the role of information in affecting behavior. Miller (1960) suggested individuals’ problem solving centered on information. New information, according to Miller, led to revisions in images, predictions, and testing and represented a component of information processing theory.

The present study's eight participants' activities supported this information processing theory of problem solving as individuals gathered new information from subsequent searches and utilized it to revise their strategies accordingly. For example, in his post-search interview Daemon explained his search strategy. "I found one actual article I found helpful and in that I saw one [term] introduction. I typed that in as a search term and was able to find more." Likewise, Dwaine used terms from a relevant article in his revised strategy." So I'm going to use of one of these keywords as subjects since this article is relevant."

Problem solving and information seeking. Wilson (1999) emphasized the problem solving perspective of information seeking in his model that included the following: problem identification, problem definition, problem resolution, and solution statement. Recent research on information problem solving expands the model to include activities that support searching in digital libraries such as searching, scanning, processing, organizing and presenting information and this was revealed by participants search behaviors in the present study (Brand-Gruwel, Wopereis, & Vermetten, 2005*:* Brand-Gruwel, Wopereis, & Walraven 2009; Laxman, 2011). The present study confirms these activities. Participants conducted searches, scanned results, processed information, as well as made references to organizing material into folders and presenting the final papers. After reviewing his results Daemon stated "Now I'm starting to get articles I can use, some are ebooks, some are them are overviews of a lot of the psychological theories." Likewise, Lesley commented on the relevancy of her results following a search. "There are fewer results, but I feel like they're still a lot in here that has to do with cognitive therapy." Dwaine's statements in his post-search interview alluded to the

processing aspect of information search. He noted “I would take those three, print them and read them.” Moreover, during this phase of the activity Betsey said “Yeah I can even picture how I’m going to put things together.”

Value of the literature to inform the study’s methodology

An examination of the literature informed the study’s methodology that incorporated the creation of the tutorial, an analysis of participants’ interaction with tool and the Ebsco databases, the use of the think aloud protocol to track their cognitive processes, as well as the value of Camtasia to provide an audio and video record of the activities. The inclusion of all of these elements in the study fostered the collection of data, the analysis of the results, and the development of appropriate recommendations for improving the tutorial and future research on the tool.

The tutorial aimed at incorporating Gagne’s principles of instructional design that focus on nine events of instruction to capture student’s attention, promote learning, and enhance retention and transfer. To further promote learning, the tutorial contained the e-learning architecture and multimedia principles espoused by Clark and Mayer (2008). In this instance the alignment of images with text, the use of the first person pronoun, the organization of the materials in segments, and the interactivity of the tool. The latter remained especially important since as Meer (2007) noted it helped engage students in using the intervention.

Comments related to the tutorial in the post-search interviews remained favorable and also underscored its usefulness as a reference tool. The majority of participants, seven out of eight, believed the tool improved the outcomes of their problem solving activities. Amy suggested the tutorial helped “with a lot of the phrasing in the search part

of it" especially "what to type in." Dwaine observed the tutorial taught him the value of reviewing results. He admitted "I guess I didn't really think at looking at the keywords. That's what helped me narrow down my search." Daemon and Lesley suggested the intervention triggered their prior knowledge of search techniques they had learned in previous library instructional classes. Kathy likened the tutorial to a tool and suggested it offered new strategies for searching. Betsey appreciated the tutorial's information on Ebsco because she was not "familiar" with it and especially the variety of sources it offered. Shelly believed the tutorial was particularly beneficial for her, a non-traditional student that required instruction in database search techniques.

Articles on the think aloud protocol; usability studies, as well as Camtasia were instrumental in facilitating an analysis of participants' cognitive processes during the problem solving activities. However, some of the findings from the authors differ from the present study. Gazda (2005) found the think aloud protocol revealed an interrelationship among individuals search strategies, navigational efficiency, and metacognitive behavior. In the present study this was noted during participants' initial search among some participants. For example, Amy appeared to have minimal search skills and this was illustrated in initial search that did not reflect knowledge of the advanced search mode, Boolean operators, or subject terms. However, following access to the tutorial, she demonstrated use of these database features in her revised searches. In Amy's post-search interview she attributed the tutorial to helping her formulate her search. "I used it to help me with a lot of the phrasing in the search part of it. It helped me with what to type in." In the present study, individuals used the tutorial to improve their search strategies and the tool also enhanced their use of metacognitive behaviors.

Likewise, the present study confirms the findings of Israel and Massey (2005) who maintained thinking aloud helped students monitor their comprehension. This was evident in the problem solving activity. During Betsey's review of her results she commented on a title "Latino English Language learners bridging achievement and cultural gaps between schools and families. Seems good, [but] I'm looking of immigration not bridging gaps." Similarly Lesley remarked "I could use to separate hmm articles that are written about education from articles about patients and subjects and psychological studies." Following review of the tutorial Susan stated "So what I'm finding [is] that possibly I'm not putting things in. I'm maybe am using too big a phrase as opposed to a couple of words in quotes."

Moreover, the present study remains in partial agreement with Tenopir et. al's (2008) research that used the think aloud protocol to capture cognitive behavior of database searchers. The authors categorized individuals' cognitive processes to feelings about the software system, the search results, the search strategy, and the task. According to the authors, participants' negative feelings were typically related to the system, search strategy, and the task. In the present study, the majority of the comments focused on the search results, the search strategy, and the task. In this instance participants' comments centered on the relevance of the results, the number of the hits, and their topic. Upon reviewing the results of her initial search, Susan stated "It's way too many, and it doesn't deal with elementary, it deals with college and it also goes into I've seen a lot of stuff dealing with schools in Turkey and schools in Korea or China." In explaining his topic Daemon said "I'm looking for more like a biography, more like a concentration of his theories, his actual theories." Lastly, the research verified conclusions by Goodwin

(2005) and Corbus, Dent, and Ondrusek (2005) on the usefulness of Camtasia in providing a means of capturing screen movements and voice for usability analysis.

Summary

The idea tactics tutorial proved to be an effective intervention for promoting participants' metacognitive strategies while problem solving. However, it remained most effective when used in short intervals to provide users ideas to overcome obstacles in the search environment. For this reason the tutorial should contain user guidelines that highlight the value of focusing on one or two tactics as well as to encourage individuals to balance their time to devising strategy, reviewing results, and examining records. Too much time spent in any of these activities can negatively affect search outcomes.

Tutorial improvements

The present study underscored the potential of the metacognitive tutorial as a stand-alone instructional tool for students. Several improvements to the tutorial would enhance its ability to provide search support for students' problem solving. Many of these modifications are minor and include visual changes to the web pages. The links to the practice database that appear on the Index pages should be removed. These links were designed to promote practice activities and they proved confusing to participants. Moreover, when the tutorial was demonstrated at the 2011 Georgia Conference on Information Literacy, one of the audience members suggested replacing the tutorial's clip art with photographs to increase participants' engagement with the content. Studies reveal pictures have a greater impact and are more entertaining than clip art. In addition, removing the quotations that appear around search terms in the tactic examples should clarify their use to designate search terms. Two participants inadvertently interpreted the quotation marks as a search technique. Utilizing different colored fonts for search terms

would be less confusing for participants in interpreting search techniques presented in the examples.

Furthermore, the tutorial would benefit from inclusion of some new content. For example, one participant remained unclear on how to access the Boolean AND operator. Providing a screen capture of the advanced search mode with a description of Boolean operators would underscore the value of this search strategy. Likewise, additional search examples should highlight the differences between keywords and subject terms in search. While some participants employed subject terms in their revised strategies, these were typically used as keywords rather than subject searches. The tutorial should also stress that the optimal number of search results varies according to the user needs. Several participants appeared confused over what constituted a sufficient results set. This remains especially important since there was reluctance among individuals to view many titles. In addition, including a section on the Main Index page that describes how Ebsco treats phrase searching in the basic search may enhance search results. One frequent error participants made during the problem solving activities included the use of the basic search mode like Google by typing in a phrase. This produced a Smart Search results set that yielded a large number of hits or no hits. Lastly, urging readers to review their search terms, database selections, and limits before and after the search may decrease the number of errors. The problem solving activity illustrated participants' carelessness in entering search terms, selecting databases, and limiting results. Although some of these mistakes centered on mistyped words that the system identified, others included more serious errors that affected search results. Unfortunately few participants attributed the irrelevance of their search results to user error in conducting the search.

Recommendations for future studies

One of the weaknesses of the present study centered on the variation among participants' search topics. This variation, that included a lack of topic development for some participants, produced search outcomes that differed in the number as well as the relevance of the hits. These differences hindered an accurate assessment of the tutorial's impact on individuals' problem solving activities. For example, conducting a Boolean search in education related databases would support topics such as Dwaine's "classroom observation tools for technology integration" and Amy's "reading activities for first grade students". On the other hand, topics such as Lesley's "mindfulness and young children, Shelly's "extrinsic versus intrinsic motivation in elementary students," and Kathy's "adult ed and multimedia in distance education" remained more specific and required the development of complex search strategies to yield relevant results. Likewise Mary's "neurobiological theories of reading" and Betsey's "immigration of English language learners" searches were broad and seemingly would have benefited from efforts to narrow the topic.

Future studies that aim to evaluate the impact of the idea tactics tutorial on individuals' problem solving, should consider efforts to minimize differences among the complexity of participants' search topics. In this instance controlling the search environment by providing all of the participants an identical topic for the activity and limiting the available databases would reduce the variability of search outcomes. This would facilitate an accurate evaluation of the tutorial's impact on problem solving behaviors. Still, researchers must weigh the advantages and disadvantages of measuring the tutorial's effectiveness utilizing identical search topics as this will effect individuals'

motivation and interest in the searches. Future studies should also consider individuals' prior knowledge of the search topics as well as their database search skills, and especially participants' familiarity with Ebsco. Utilizing a pre-survey to track participants' domain, system and metacognitive knowledge, as well as their age, their major, their student status, and the year they obtained their undergraduate degree would allow for conclusions on the impact of the tutorial on search results as well as the tool's effect on non-traditional students, individuals use of metacognitive strategies, and participants with varying database skills.

The present study suffered from variations in participant's behavior in the think aloud too. Some individuals detailed their activities and thoughts during the problem solving activities producing rich transcripts of qualitative data. On the other hand, a few of the participants remained quiet while devising search strategy or uttered non-descript words such as "great" when reviewing results. These individuals failed to adequately describe their feelings or motivations during their problem solving. This may have stemmed from an introverted personality or a lack of understanding of the think aloud protocol requirements. Future efforts to evaluate the tutorial using the think aloud protocol, should consider interviewing potential participants and including a "test think aloud" session to determine individuals' abilities to think out loud.

Lastly, participant recruitment efforts in the present study remained difficult. Future efforts should consider arranging with education faculty prior to the onset of the term to visit their graduate classes during the second week of the semester. During the visit the researcher should provide an illustration of the tutorial along with the description of the research and highlight participants' need to think aloud during the activity.

Benefits to the students including gaining new search techniques and an increased awareness of metacognitive strategies should be outlined during these class visits. In addition, recruitment efforts may need to include soliciting students from nearby universities. However, this will require separate institutional review board applications with the universities. Lastly, providing more incentives to participants may facilitate greater student involvement in the research.

Implications

The metacognitive tutorial would especially support the provision of search strategies for self-directed learners in a constructivist learning environment. It also offers potential in reinforcing traditional library instruction. In this instance including a link to the tutorial on a course page in a learning management system or from a library web page would facilitate its use as a reference tool.

In addition, while this study focused on education graduate students, the tutorial would support the enhancement of metacognitive skills for undergraduate students and individuals in a variety of disciplines. The latter would require modification of the tutorial to support search techniques in other non-Ebsco databases such as ScienceDirect, ACM Digital Library, and IEEE Explore as well as ProQuest**.** For undergraduate use, a pre-survey of students' knowledge of search techniques would help inform its suitability for this audience.

Lastly, future study designs should consider other theoretical frameworks and particularly the variety of perspectives on information behavior. One such perspective that supports the application of idea tactics includes Dervin's (1992) sense-making concept. Dervin described sense-making as a "theoretic net, a set of assumptions and a set

of methods" that focused on how individuals make sense of their experiences (p. 61). In sense-making individual's information use remains a self-construct dependent on the current situation as well as the strategies the user devises to bridge the discontinuities in his environment. To this end, examining participants' utilization of the idea tactics from the sense-making approach offers another lens to illustrate the impact of the tool on the search process.

APPENDIX A

Informed Consent Think Aloud Problem Solving Activity

I am a doctoral candidate in instructional technology at Towson University. I am conducting research on enhancing the information seeking behaviors of education graduate students. This activity represents the second phase of my research. It centers on think aloud problem solving exercises that are recorded using a screen capture software. All students will work individually to locate information using the Ebsco databases to solve an information problem. They will have 50 minutes to complete the tasks. Following the activity the researcher will conduct a follow-up interview to identify participants' reactions to the exercise. All of the data gathered represents my dissertation research.

Your opinions and information are confidential and any of the information gathered from the research will not be seen by any other students, faculty, staff, or anyone outside the university. You will utilize the unique ID number you selected in completing the metacognitive questionnaire.

I expect the activity and interview to take a total of 60 minutes of your time. Participants will be compensated with a twenty-five dollar gift certificate from GiftCertificate.com.

Participating in this study is completely voluntary. Even if you decide to participate now, you can change your mind and stop at any time. You may choose to skip any part of the activity you do not wish to participate in.

The session will be video and audio taped to facilitate the transcription of the data. No identifying information about you will be released at anytime to anyone.

If you have questions about this research study please contact Barbara Blummer bblumm1@students.towson.edu or 301-805-7428

If you have questions regarding your rights as a participant in research, please contact the Debi Gartland, Chairperson of the Institutional Review Board for the Protection of Human Participants at Towson University at (410) 704-2236.

Signature Date Print name

THIS PROJECT HAS BEEN REVIEWED BY THE INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN PARTICIPANTS AT TOWSON UNIVERSITY (410-704-2236)

TOWSON
UNIVERSITY

APPROVAL NUMBER: 11-A068

To: Barbara Blummer
6501 Allview Drive
Columbia MD 21046

From: Institutional Review Board for the Proctection of Human Subjects, Steven Mogge, Member

Date: Thursday, May 19, 2011

RE: Application for Approval of Research Involving the Use of Human Participants

Office of University
Research Services

Towson University
8000 York Road
Towson, MD 21252-0001

t. 410 704-2236
f. 410 704-4494

Thank you for submitting an Application for Approval of Research Involving the Use of Human Participants to the Institutional Review Board for the Protection of Human Participants (IRB) at Towson University. The IRB hereby approves your proposal titled:

Evaluating the effectiveness of a metacognitive tool on education graduate students' search behaviors in digital libraries.

If you should encounter any new risks, reactions, or injuries while conducting your research, please notify the IRB. Should your research extend beyond one year in duration, or should there be substantive changes in your research protocol, you will need to submit another application for approval at that time.
We wish you every success in your research project. If you have any questions, please call me at (410) 704-2236.

CC: Jeffrey Kenton
File

TOWSON
UNIVERSITY

Date: Thursday, May 19, 2011

NOTICE OF APPROVAL

TO: Barbara Blummer **DEPT:** EDTL

PROJECT TITLE: *Evaluating the effectiveness of a metacognitive tool on education graduate students' search behaviors in digital libraries.*

SPONSORING AGENCY:

APPROVAL NUMBER: 11-A068

The Institutional Review Board for the Protection of Human Participants has approved the project described above. Approval was based on the descriptive material and procedures you submitted for review. Should any changes be made in your procedures, or if you should encounter any new risks, reactions, injuries, or deaths of persons as participants, you must notify the Board.

A consent form: [√] is [ ] is not required of each participant

Assent: [ ] is [ ] is not required of each participant

This protocol was first approved on: 19-May-2011

This research will be reviewed every year from the date of first approval.

Steven Mogge bg

Steven Mogge, Member
Towson University Institutional Review Board

APPENDIX B Post-problem solving activity semi-structured interview questions

1. Discuss search strategies, obstacles that you encountered during the activity, and satisfaction level with the results. This may include problems with the think aloud protocol, search strategy, or difficulty finding information on the website.

2. Comment on the helpfulness of the tutorial.

APPENDIX C Code Tree

- Search
  - Initial search
    - Choose databases
    - Results review
    - Initial strategy
  - Revised Search
    - Judge relevance
      - Journals
      - Classroom
    - Narrowing down
      - Limit results
    - New strategy
      - Age
      - Choose databases
      - Search terms
      - Subject terms
      - Subject thesaurus
      - Quotation marks
      - Search type
      - Truncate
    - Results – review and revision
      - Interest
      - Subject terms

- Keywords
- Page Length
- Refinement of concept terms
- Filter
- Full text availability
- Results number and revision

- Final plans
- Folder

- Ebsco
  - Accessibility
- Title-relevance estimate
- Time
- Skills acquired
  - New
  - Remembering
- Errors
  - Initial errors
  - Continuous errors
  - Ebsco errors
- Uncertainty
- Topic identification
  - Topic clear
    - Goal
  - Topic unclear

Tutorial

Main Index

Relevance Index

Think example

Catch example

Application of catch tactic

Notice example

Application of notice tactic

Application of relevance index tactics

Strategy index

Break example

Application of strategy index tactic

Number index

Change example

Application of change tactic

Meditate example

Application of meditate tactic

Create example

Application of create tactic

Application of number index tactics

Evaluate index

Wander example

Jolt example

Application of jolt tactic

Application of evaluate index

Participants' perspectives-search obstacles

- Selecting terms
- Think aloud
- Number of hits
- Strategy

Participants' reflections- general

- Satisfaction
- Time
- Skills
- Librarian

APPENDIX D Code Dictionary

Accessibility (Ebsco)-The importance of accessibility for articles in Ebsco.

Age (New strategy)-Participant's revised search strategy focuses on age of subjects.

Application of catch tactic- Participant's application of catch tactic to recognize an unproductive search and institute a new search approach.

Application of change tactic- Participant's application of change tactic to institute a new search behavior, keyword or strategy.

Application of create tactic-Participant's application of the create tactics' advice to create a search strategy by identifying relevant keywords, search fields and databases.

Application of evaluation index- Participant's application of the Evaluation Index's focus on evaluating the results to improve outcomes.

Application of jolt tactic-Participant's application of the jolt tactic's suggestion to view the search in a new way.

Application of meditate tactic- Participant's application of mediate tactic's focus on analyzing the search strategy.

Application of notice tactic- Participant's application of notice tactic's focus on recognizing the appearance of any clues that affect the interpretation of the question.

Application of the number index-Participant's application of the Number Index's tactics to broaden or narrow a search.

Application of relevance index- Participant's application of the Relevance Index's suggestion to think of search goals, catch an unproductive search and to notice clues.

Application of strategy index- Participant's application of the Strategy Index's suggestion to change search habits, focus on thought processes, and consider different perspectives.

Break example- Comments about the break example and participant's time spent on the page.

Catch example- Comments about the catch example and participant's time spent on the page.

Change example- Comments about the change example and participant's time spent on the page.

Choose databases (Initial search)-Participants' selection of databases for the initial search.

Choose databases (New strategy)-Participant's revised search strategy focuses on database selection.

Classroom (Judge relevance)-Participant focuses on the relevance of results to use in the classroom.

Continuous errors (Errors)-Errors made by participants that stem from their adoption of recommendations from the tutorial.

Create example-Comments about the create example and participant's time spent on the page.

Ebsco-Comments by the participants on Ebsco or Academic Search Premier**.**

Ebsco errors (Errors)-Errors relating to the peculiarities of the Ebsco database.

Errors-Typing and other mistakes made by participant in their search. Some were recognized by participant and others were not.

Evaluation index- Comments about the Evaluation Index and participant's time spent on the page.

Filter (**Results review and revision)-**Participant seeks to filter out the material that is not relevant in the search results.

Final plans-Participant's plans after locating relevant materials in search results.

Folder (Final plans)-Participant seeks to place items of relevancy in a folder.

Full text availability (**Results review and revision)-**Participant focuses on the availability of full text in the results.

Goal (Topic clear)-Participant's goals for the search results.

Interest (Results review and revision)-Participant focuses on their interest in the article in reviewing the results.

Initial errors (errors)-This node traces errors participants made in the initial search.

Initial search-The initial (first) search the participant performed in the problem solving activity.

Initial strategy (Initial search)-Participants' strategy for the initial search

Jolt example- Comments about the jolt example and participant's time spent on the page.

Journals (Judge relevance)-Participant bases relevancy of results on journal sources.

Judge relevance- Participants reviews results and determines their relevance to his/her topic.

Judge relevance (Revised search)-Participant's efforts to judge the relevance of results in revised search.

Keywords (Results review and revision)-Participant focuses on the keywords in the results to locate new search terms for subsequent searches.

Librarians (**Participant's perspectives general)**-Participants perspectives on librarians.

Limit results (Narrowing down)-Participant focuses on limiting results to a particular category.

Main index-Participant's comments about the Main Index and participant's time spent on the page.

Meditate example- Comments about the meditate example and participant's time spent on the page.

Narrowing down (Revised search)-Participants' strategies for narrowing down search results.

New (skills acquired)-Search skills as a new concept to participants.

New strategy-Participant verbalizes a new strategy for their revised searches.

Notice example-Comments about the notice example and participant's time spent on the page.

Number of hits (**Participant's perspectives search obstacles)**-Problems participants noted with too many or too few results.

Number index- Comments about the Number Index and participant's time spent on the page.

Page length (**Results review and revision)**-Participant considers articles' page length in reviewing results.

Participant's perspectives general- Participant's thoughts outlined in the post-search interview.

Participant's perspectives search obstacles- Obstacles participants encountered during their problem solving exercise and with search in general.

Quotation marks (New strategy)-Participant's revised search strategy focuses on use of quotation marks.

Refinement of concept terms (Results review and revision)-Participant refines their search topic as they examine results.

Remembering (Skills acquired)-Participants identify remembering as a search skill.

Results number and revision-Number of records participant received and their reaction to the hits.

Results review (Initial search)-Participant reviews results from the initial search

Results review and revision-Participant reviews the search results of the revised search.

Revised search-Participants revised searches after exposure to the tutorial.

Satisfaction (**Participant's perspectives general)**-Participants satisfaction level with the results of the problem solving activity.

Search terms (New Strategy)-Participant's revised search strategy focuses on search terms.

Search type (New Strategy)-Participant's revised search strategy focuses on basic or advanced search mode.

Selecting terms (**Participant's perspectives search obstacles)**-Problems participants encountered with determining the most appropriate search terms**.**

Skills acquired-The value of skills acquired in the search process.

Skills (Participant's perspectives general)-Participants comments regarding search skills in the post-search interview.

Strategy index- Comments about the Strategy Index and participant's time spent on the page.

Strategy (**Participant's perspectives search obstacles)**-Problems participants encountered with devising their search strategy.

Subject terms (Results review and revision)-Participant examines the subject terms to devise a new search.

Search terms (New Strategy)-Participant's revised search strategy focuses on subject terms.

Search thesaurus (New Strategy)-Participant's revised search strategy focuses on using subject thesaurus of search results.

Think aloud (Participant's perspectives search obstacles)-Problems participants encountered with the think aloud protocol.

Think example- Comments about the think example and participant's time spent on the page.

Time- (Participant's perspectives general) Participants' comments on time in the post-search interview.

Title relevance estimate-Comments made by the participant concerning the requirements of the paper and whether the articles would be applicable.

Topic clear (Topic identification) - Participant describes a well-formulated topic.

Topic identification- Participant provides a description of the topic.

Topic unclear (Topic identification)- Participant does not verbalize a clear topic.

Truncate (New Strategy)-Participant's revised search strategy focuses on truncating terms.

Tutorial- Comments about the tutorial and participant's time spent in the tool.

Uncertainty-Participants, especially those new to the search environment, indications of uncertainty.

Wander example- Comments about the wander example and participant's time spent on the page.

APPENDIX E Participants' Searches

Table 1

Dwaine's Searches and Number of Hits During his Problem Solving Activity

Classroom observation tool technology integration (includes Education Research co)-[YOUR] 13,151 Classroom observation AND technology integration-20 Classroom observation AND technology assessment-4

Table 2

Amy's Searches and Number of Hits During Her Problem Solving Activity

Reading activities first grade-1 Early literacy reading activities for a first grade student-[YOUR] 18344 First grade student (SU) and reading activities (field)-0 First grade student (all text) and reading activities (field)-22

Table 3

Lesley's Searches and Number of Hits During Her Problem Solving Activity

mindfulness and young children-4 Mindfulness and early childhood education-231 [YOUR] Mindfulness and early childhood education (peer reviewed)-207 [YOUR] Mindfulness and early childhood education (specifies date)-231(error?) Mindfulness and early childhood education (peer reviewed)-207 Mindfulness and early childhood education and kindergarten-0 Mindfulness and early childhood education and public school-1 [YOUR] Mindfulness and early childhood education (selects only education research complete)-170[YOUR] Mindfulness and early childhood education (scholarly, peer reviewed/dates?)-153 Mindfulness and early childhood education AND teach*-66 Mindfulness and early childhood education AND teach* AND class*-19 [YOUR] Mindfulness and early childhood education AND teach*-66 Mindfulness AND teach* AND class*-24 Mindfulness AND teach* AND elementary*-7

Table 4

Betsey's Searches and Number of Hits During Her Problem Solving Activity

Immigration of ells-2
Immigration of ells and Maryland-0
Culture of ells-4
Immigration of students-313
Immigration of students and languages-15
Sociocultural aspects-155
Sociocultural aspects and english language learners-0
(same search with TRC, ERC, PriS)-1
Sociocultural and english learners (same search with databases)-56
Sociocultural and English learners (adds research starters)-56
CLICKS ON Education Research Complete-55

Table 5

Kathy's Searches and Number of Hits During Her Problem Solving Activity

Adult ed* AND multimedia AND distance (specified publication date)32
Adult ed* AND multimedia AND distance OR delivery systems 77,011
SAME SEARCH (removes databases)34,547
SAME SEARCH (adds databases, date)42,370
MODIFIES SEARCH adds AND higher ed*-829
Adult ed* AND multimedia AND distance OR delivery systems NOT test* NOT Access*627
NARROWS SEARCH with Thesaurus higher ed, distance edu education technology online courses universities and colleges47

Table 6

Mary's Searches and Number of Hits During Her Problem Solving Activity

Neurobiological -13119 (includes PsycInfo)
Neurobiological define-9
Neurobiological Theories of reading-went to tutorial
Neurobiological theories of reading-1035 [YOUR]
Neurobiological theories models of reading-2947 [YOUR]
Theories of reading neuro cognitive-1
Theories of reading-2297
Theories of reading phonological processing-5
Theoretical models of reading-125
Theoretical models of reading maotts-45225
Theoretical models of reading maots-1[YOUR]
Theoretical models of reading-125
Theoretical models of reading-81 (adds new database Eric deletes PsycInfo)
Theoretical models of reading neurobiological-844 [YOUR]
Shaywitz-194
Shaywitz models of reading-90
Lyon-39896
Lyon models of reading-2046
Maots models of reading-55[YOUR]
Standovich models of reading-9533 [YOUR]
Models of reading cognitive -6343
Theoretical models of reading cognitive-809

Table 7

Daemon's Searches and Number of Hits During His Problem Solving Activity

Jean pieget and learning theories- 0
Did you mean Jean piaget? -323
Jean piaget and cognitive development-88
Jean piaget AND Cognitive development AND theor* (ERC,ERIC, PR, PychAR, PychI)-436
SAME SEARCH NARROWS WITH SUBJECT Thesaurus piaget theory-39
Piagetian theory AND overview-76
Piagetian theory AND overview AND cognitive-61
Piagetian theory AND education* AND cognitive AND teach*-494
Jean piaget AND cognitive learning theory-13
Jean piaget AND "cognitive learning theor*"-15
Jean piaget AND "cognitive theory theory" AND developmental psychology-5
Jean piaget AND developmental psychology-425
Jean piaget AND "developmental psychology" AND introduction-27

Table 8

Shelly's Searches and Number of Hits During Her Problem Solving Activity

Extrinsic vs intrinsic motivation in elementary students-4912
Update with present to 2010,- 967
'intrinsic' 'extrinsic' 'motivation'-36
'intrinsic' 'extrinsic' 'motivation' 'elementary'-0
Grades (SU) AND intrinsic or extrinsic AND 'motivation' elementary-0
Elementary education (SU) AND intrinsic or extrinsic AND 'motivation' elementary -2
Elementary education (SU) AND intrinsic or extrinsic AND 'motivation'-9
Elementary education (SU) AND intrinsic or extrinsic AND 'grading-0
Elementary education (SU) AND intrinsic or extrinsic AND grades-4
Elementary education (SU) AND intrinsic or extrinsic OR grades and motivation-1309
SAME SEARCH WITH dates 2009-2011)-351
Elementary education (SU) AND intrinsic or extrinsic OR grades and motivation (checks US)-33

APPENDIX F Rating Form for Last Search

Scoring was based on a five point Likert scale. 5 = highest 1=lowest,

	Failed	Below average	Average	Above Average	Excellent
Relevant					
Authoritarian					
Answered Problem					
Quality of Response					

APPENDIX G Search Ratings

Table 1a

Dwaine's First Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant			3		
Authoritative				4	
Answered Problem			3		
Quality of Response		2			

Note. Dwaine's first search: Classroom observation tool technology integration (included Education Research Complete) This search produced 13,151 hits.

Table 1b

Dwaine's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant				4	
Authoritative				4	
Answered Problem				4	
Quality of Response				4	

Note. This search: Classroom observation AND technology assessment yielded 4 results.

Table 2a

Amy's First Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant		2			
Authoritative			3		
Answered Problem	1				
Quality of Response	1				

Note. Reading activities first grade. This search produced 1 result.

Table 2b

Amy's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant				4	
Authoritative				4	
Answered Problem				4	
Quality of Response				4	

Note. First grade student (all text) and reading activities (field). This search yielded 22 hits.

Table 3a

Lesley's First Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant		2			
Authoritative				4	
Answered Problem		2			
Quality of Response		2			

Note. Mindfulness and young children**.** She obtained 4 results.

Lesley's Last Search

Category	Failed	Below average	Average	Above Average	Excellent
Relevant			3		
Authoritative				4	
Answered Problem			3		
Quality of Response			3		

Note. Mindfulness AND teach* AND elementary*. This search produced 7 results.

Table 4a

Betsey's First Searches

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant	1				
Authoritative		1.5			
Answered Problem	1				
Quality of Response	1				

Note. Immigration of ELLs. It yielded 2 hits. Her second search was immigration of ells and Maryland and it produced zero results. These scores were averaged.

Table 4b

Betsey's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant				4	
Authoritative				4	
Answered Problem				4	
Quality of Response				4	

Note. Sociocultural and English learners (education research complete). This search produced 56 results.

Table 5a

Kathy's First Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant		2			
Authoritative				4	
Answered Problem		2			
Quality of Response			3		

Note. Adult ed* AND multimedia AND distance (all databases).

Table 5b

Kathy's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant	1				
Authoritative			3		
Answered Problem	1				
Quality of Response		2			

Note. Adult ed* AND multimedia AND distance OR delivery systems AND Higher ed* NOT test* NOT Assess* publication date 2001-2011, narrowed search with Thesaurus higher ed, distance ed, education technology. This search produced 47 hits.

Databases included: Academic Search Premier, Business Source complete, CINAHL, ERIC, PsycInfo, Regional Business News, Education Research Complete, Military & Government Collection, MAS Ultra, Socioindex, Psychology and Behavioral Sciences Collection, Computer Science Index, Professional Development Collection, Library & Information Science and Technology Abstracts, Social Science Abstracts, Women's Studies International, Econlit, Music Index, Communication and Mass Media, Teacher Reference Center, Abstracts in Social Gerontology, International Bibliography of Theatre & Dance, Art Abstracts, PsycArticles, Ebook Collection, Human Resources Abstracts, American History and Life, Historical Abstracts, Humanities Abstracts, Philosophers Index

Table 6a

Mary's First Searches

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant		2			
Authoritative			3		
Answered Problem		2			
Quality of Response		2			

Note. Neurobiological (included PsycInfo). She obtained 13119 results. Her second search was neurobiological define and it produced 9 results. These scores were averaged.

Table 6b

Mary's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant		2			
Authoritative			3		
Answered Problem		2			
Quality of Response		2			

Note. Theoretical models of reading cognitive (included Eric). The search yielded 809 hits.

Table 7a

Daemon's First Searches

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant			3		
Authoritative			3.5		
Answered Problem		2.5			
Quality of Response			3		

Note. Jean pieget and learning theories. This search yielded no results. However the database responded with did you mean Jean Piaget that contained 323 hits. His second pre-tutorial search, jean piaget and cognitive development produced 88 results. These scores were averaged.

Table 7b

Daemon's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant				4	
Authoritative				4	
Answered Problem				4	
Quality of Response				4	

Note. Jean piaget AND "developmental psychology" AND introduction (includes Education Research Complete, Eric, Primary Research, PsycArticles, PsycInfo). This search produced 27 hits.

Table 8a

Shelly's First Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant			3		
Authoritative			3		
Answered Problem			3		
Quality of Response			3		

Note. Extrinsic vs intrinsic motivation in elementary students. This search produced 4912 results.

Table 8b

Shelly's Last Search

Category	Failed	Below Average	Average	Above Average	Excellent
Relevant				4	
Authoritative				4	
Answered Problem				4	
Quality of Response				4	

Note. Elementary education (SU) AND intrinsic or extrinsic OR grades and motivation (limited to US and publication dates 2009 to 2011). She obtained 33 results.

APPENDIX H Scatter Plot Diagrams and Bar Graphs

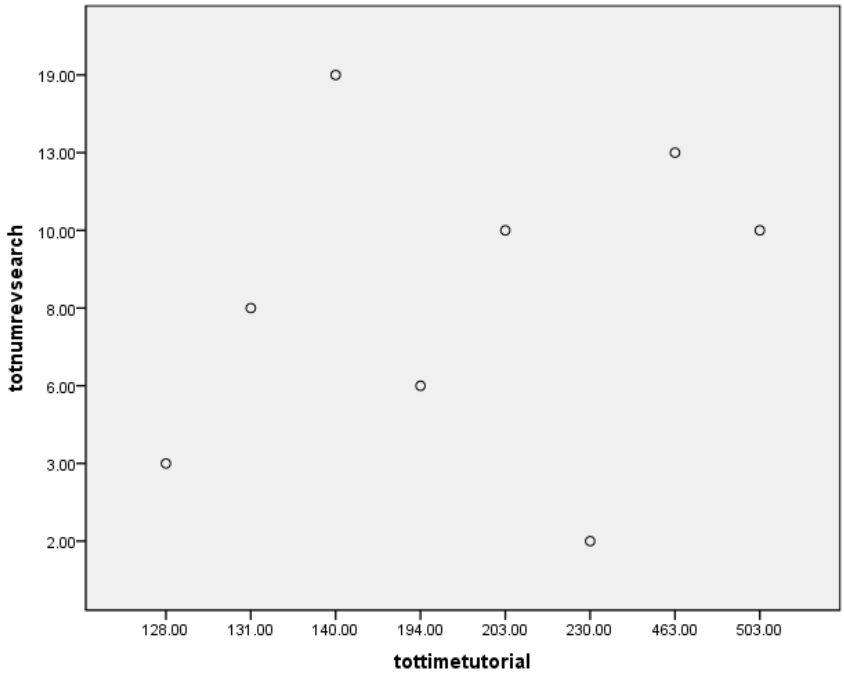

Figure 1. Total time in tutorial had no impact on the number of revised searches performed.

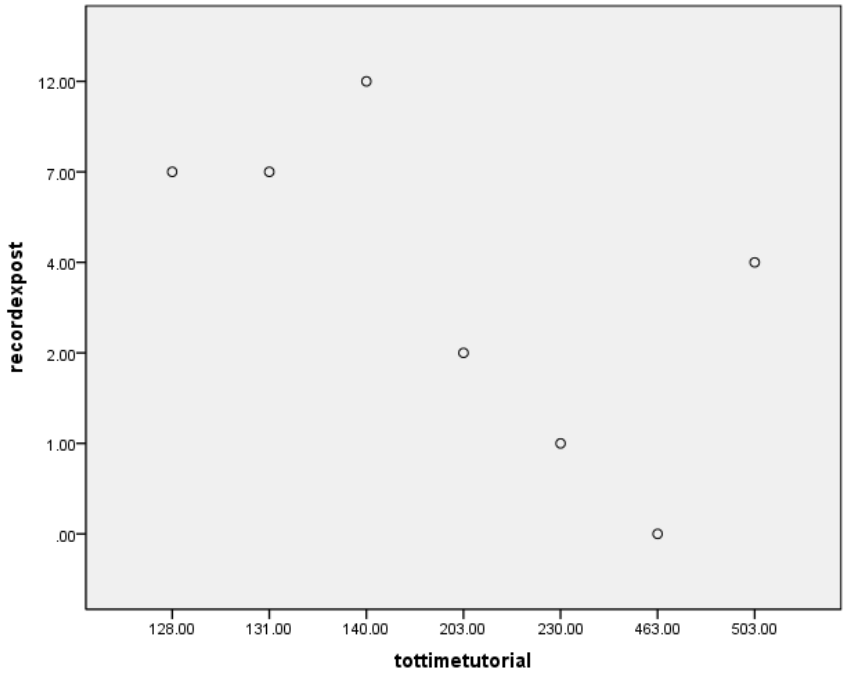

Figure 2. Total time in tutorial led to decreased records examined.

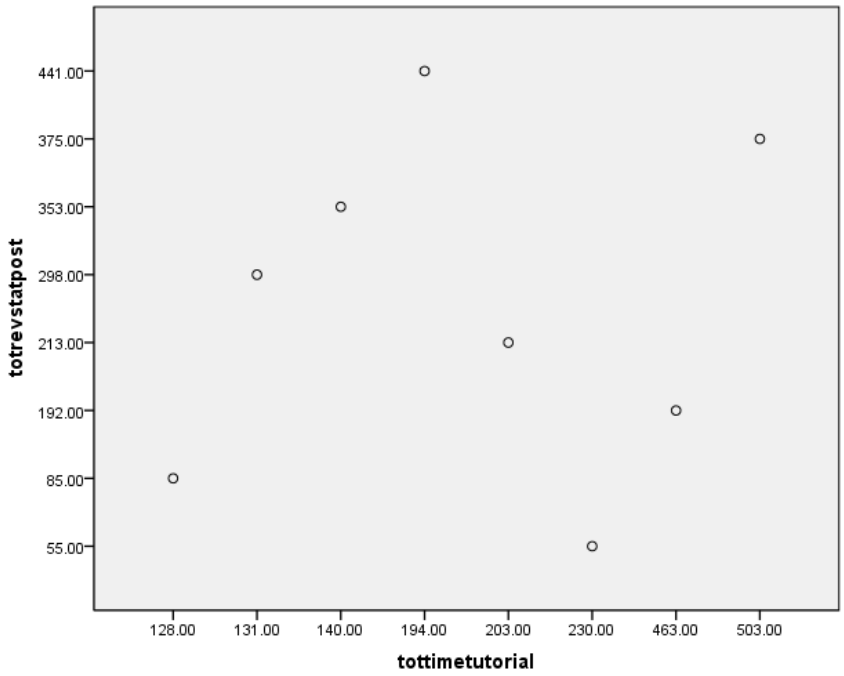

Figure 3. Time spent in tutorial led to more time revising search strategy.

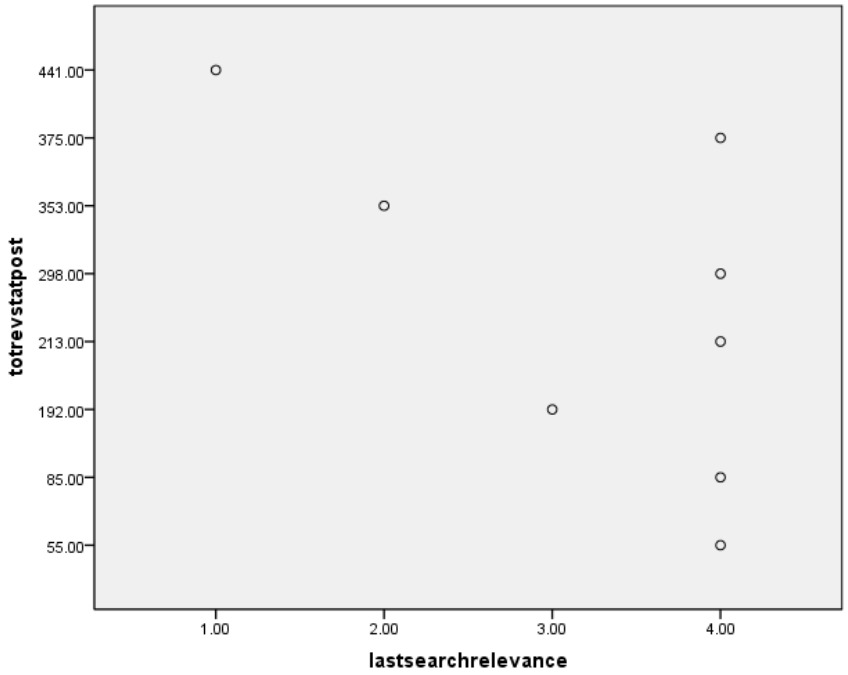

Figure 4. Time spent devising search strategy decreased the relevance of the last search for some participants.

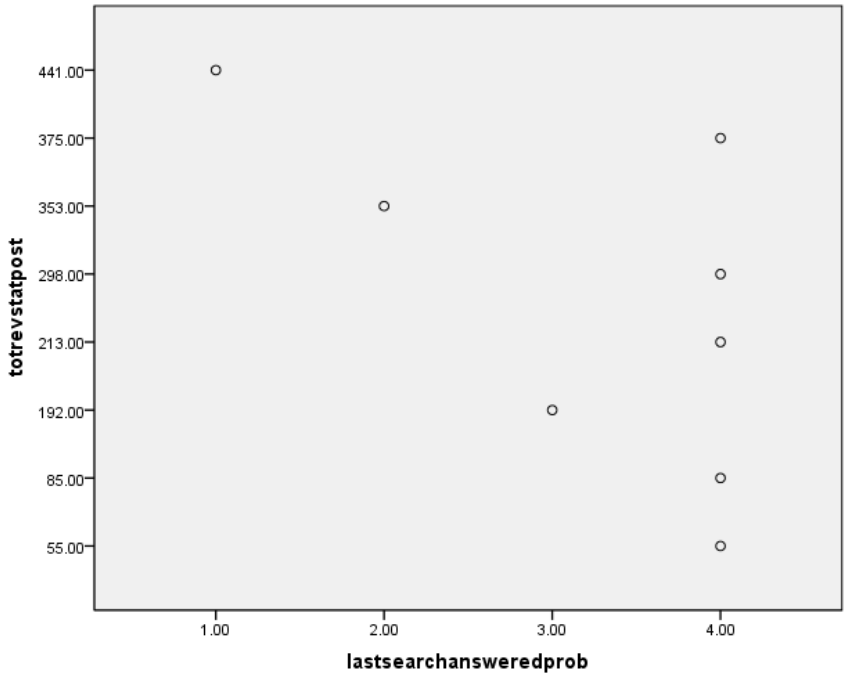

Figure 5. Time spent devising search strategy decreased ability of the last search to answer the problem for half of the participants.

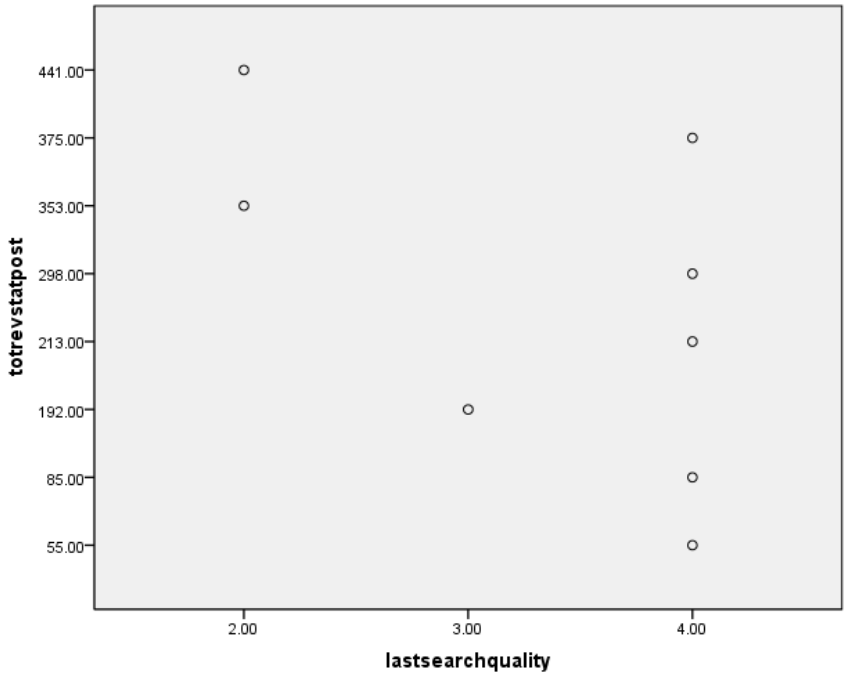

Figure 6. Time spent devising search strategy decreased quality of the last search for half of the participants.

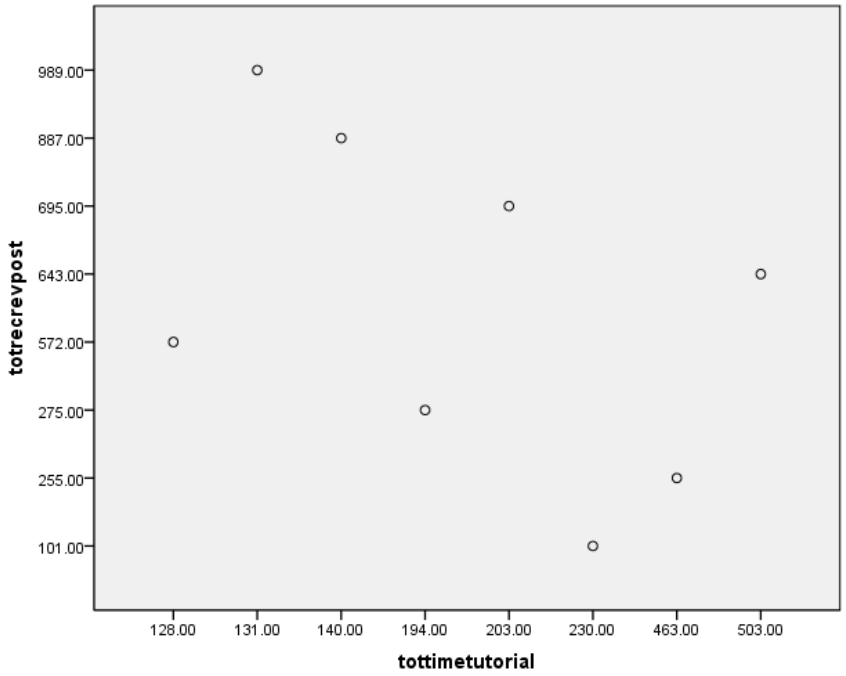

Figure 7. Time in tutorial led to less time reviewing records for half of the participants.

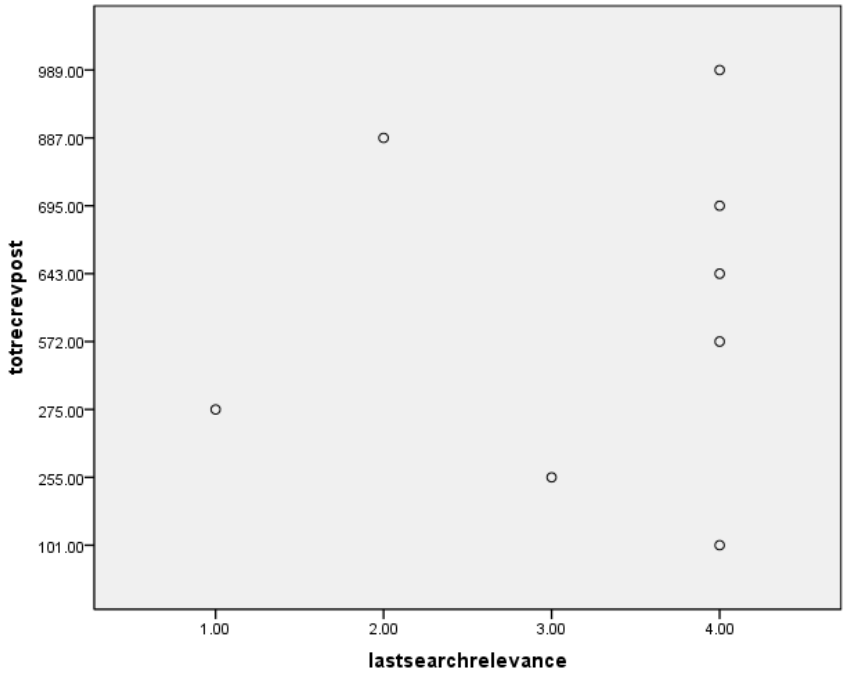

Figure 8. Time spent reviewing results decreased the relevance of the last search for half of the participants.

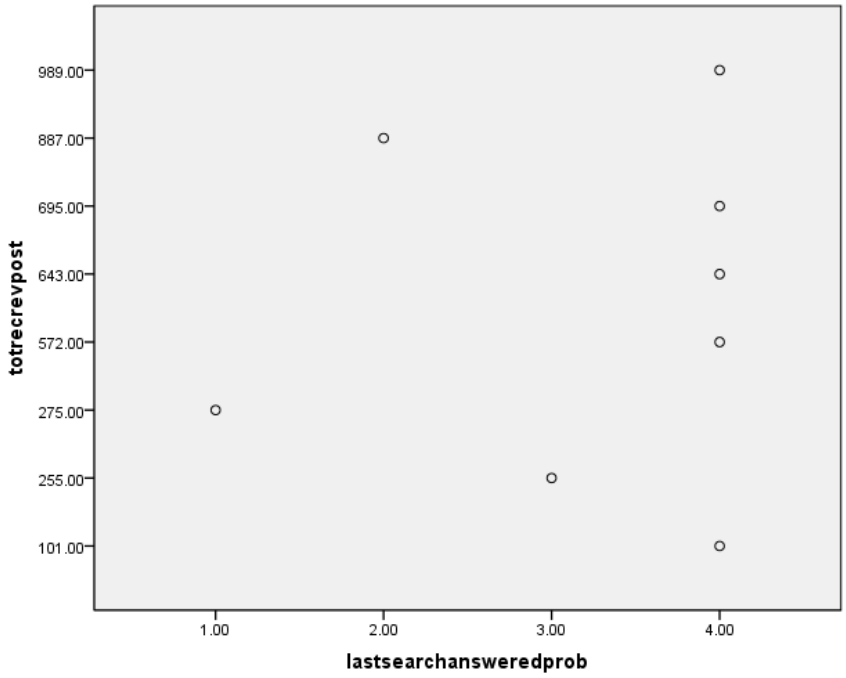

Figure 9. Time spent reviewing results decreased the ability of the last search to answer the problem for half of the participants.

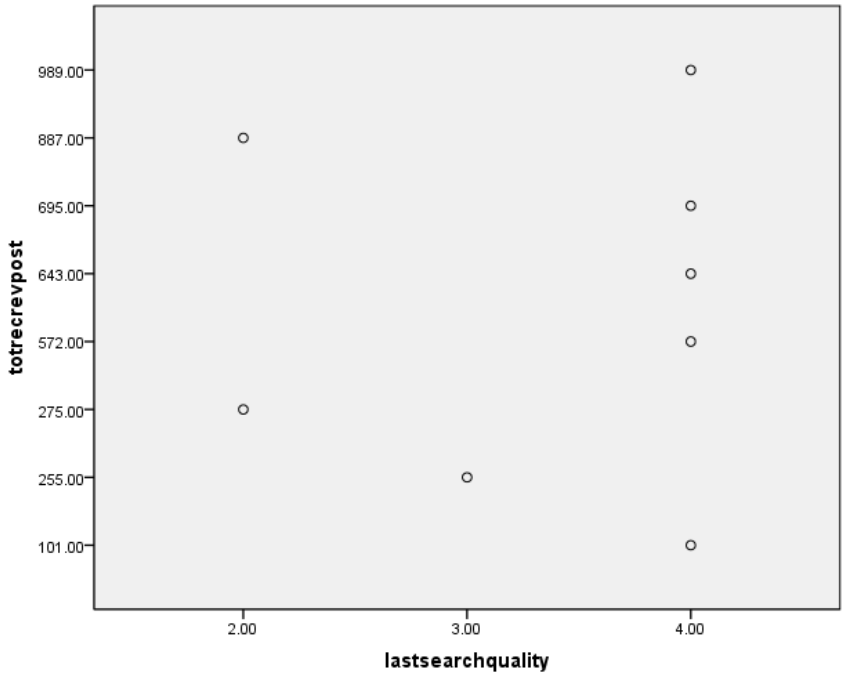

Figure 10. Time spent reviewing results decreased the quality of the last search for half of the participants.

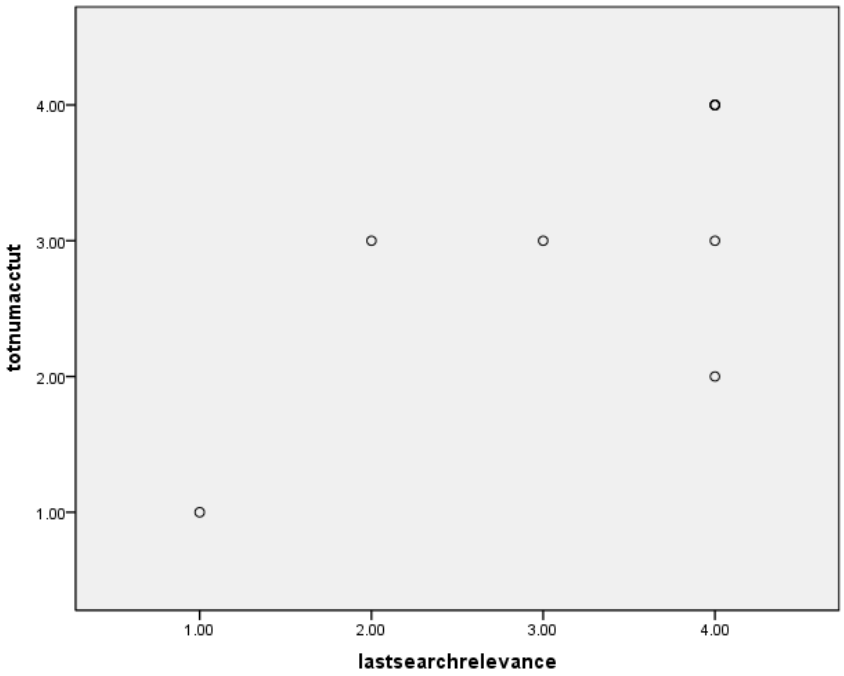

Figure 11. Increased accesses to the tutorial led to higher scores for the relevance of the results for half of the participants.

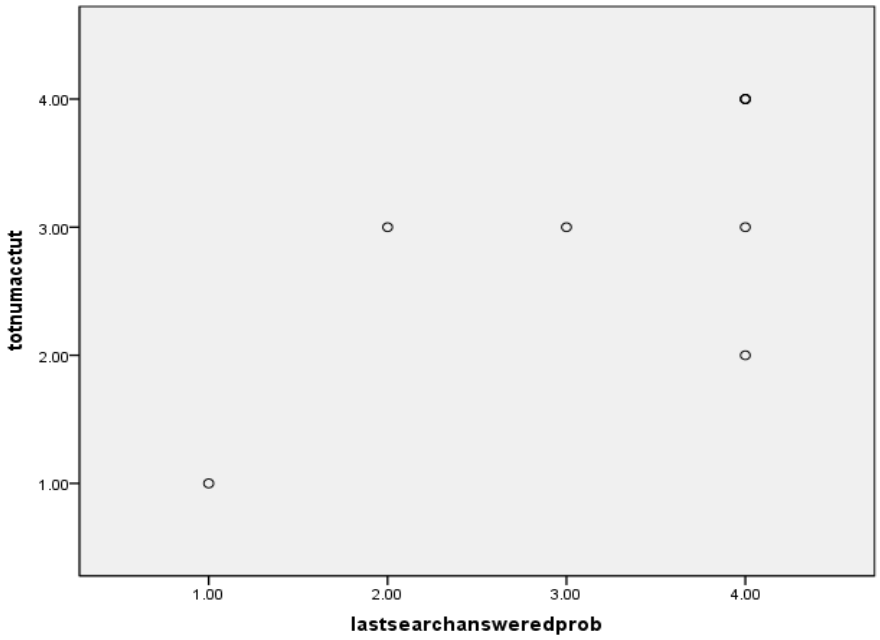

Figure 12 . Increased accesses to the tutorial led to higher scores for the ability of the last search to answer the problem for half of the participants.

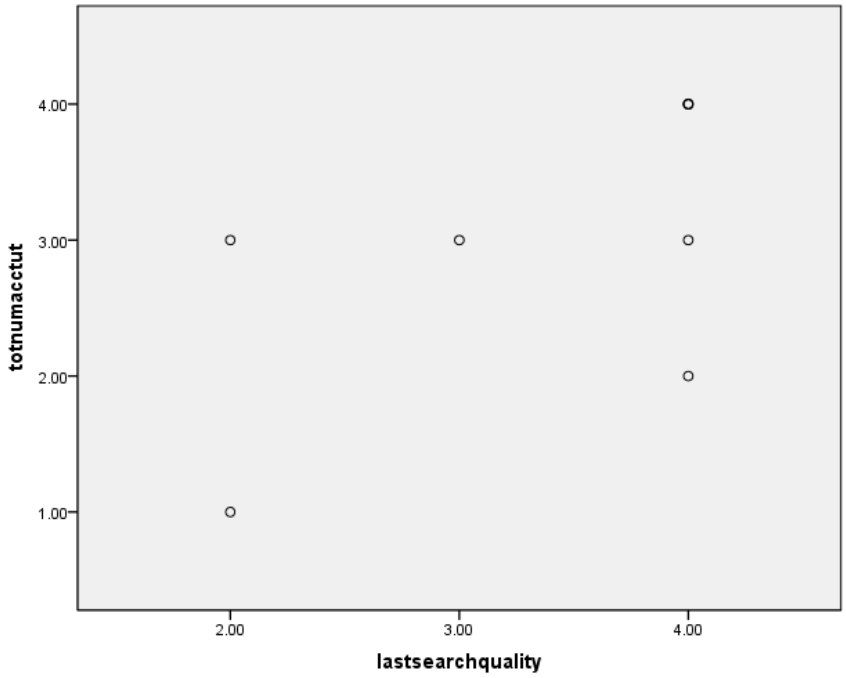

Figure 13. Increased accesses to the tutorial led to higher scores for the quality of the last search for some participants.

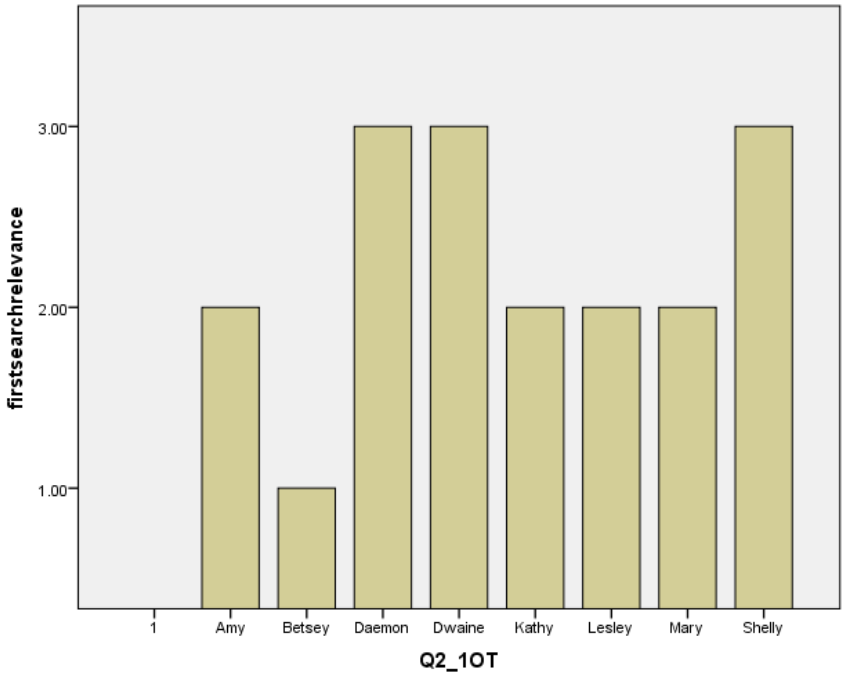

Figure 14. Participants' first search rating for relevance of the results.

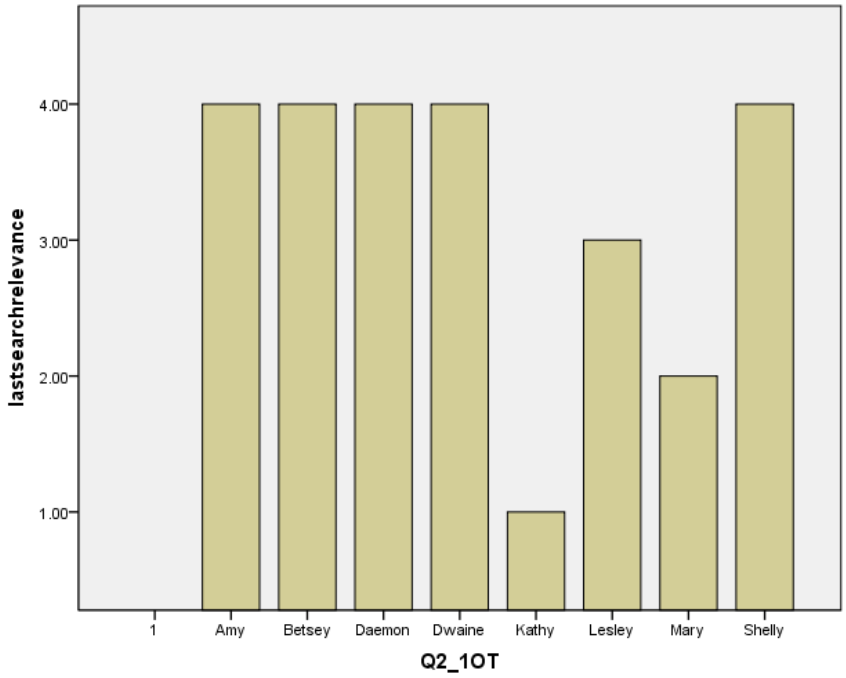

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Figure 15. Participants' last search rating for relevance of the results.

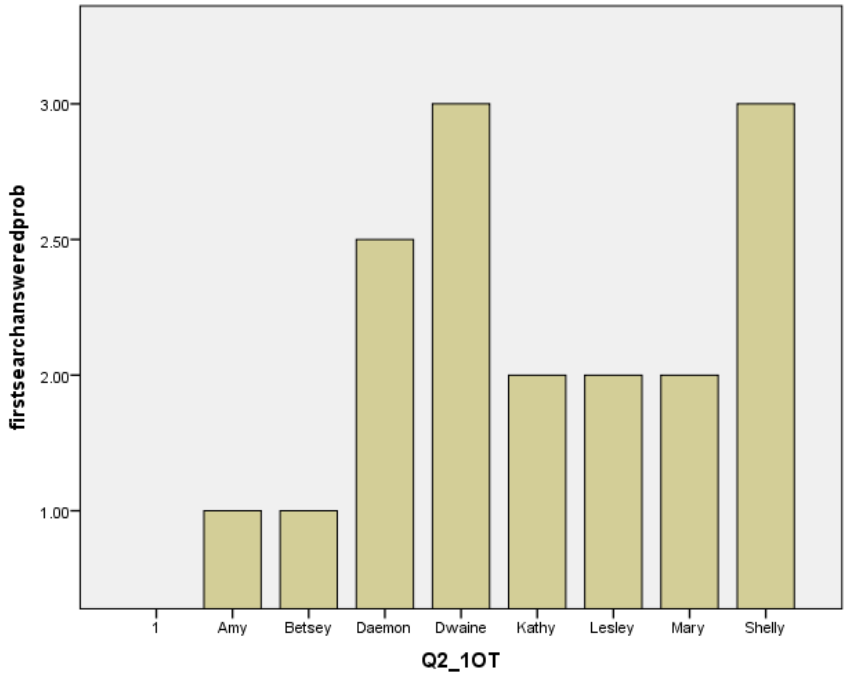

Figure 16. Participants' first search rating for results' ability to answer the problem.

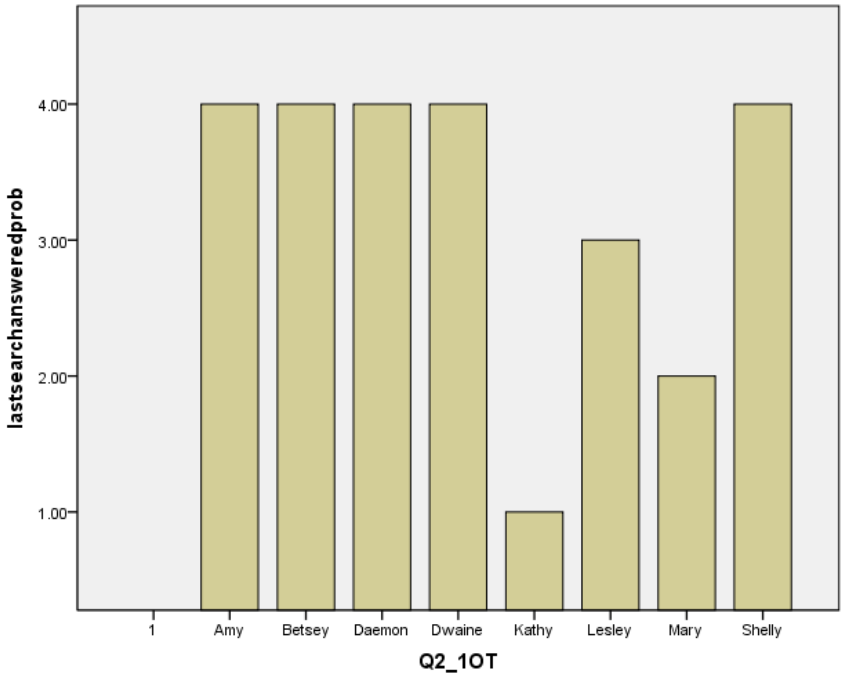

Figure 17. Participants' last search rating for results' ability to answer the problem.

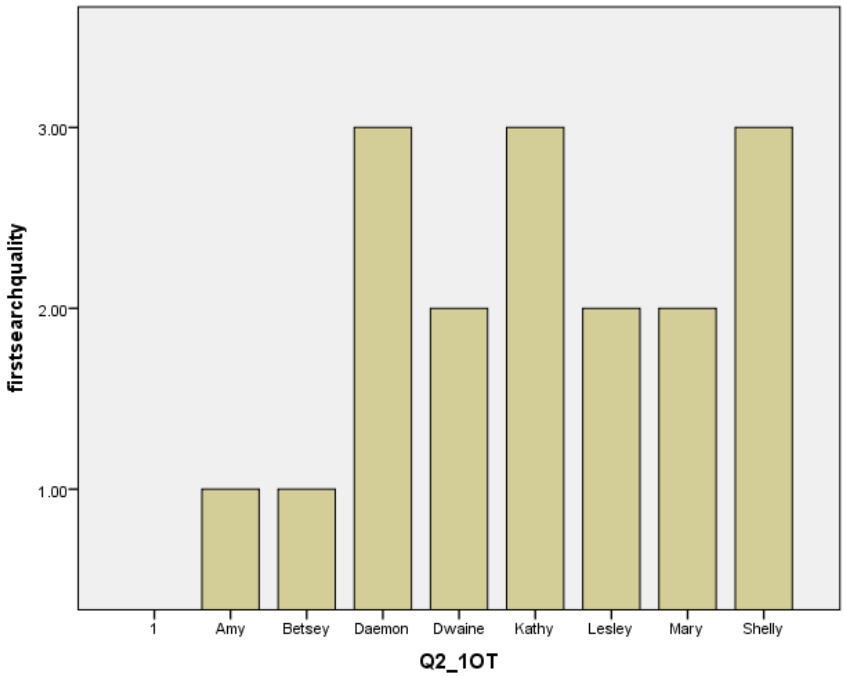

Figure 18. Participants' first search rating for results' quality of the response.

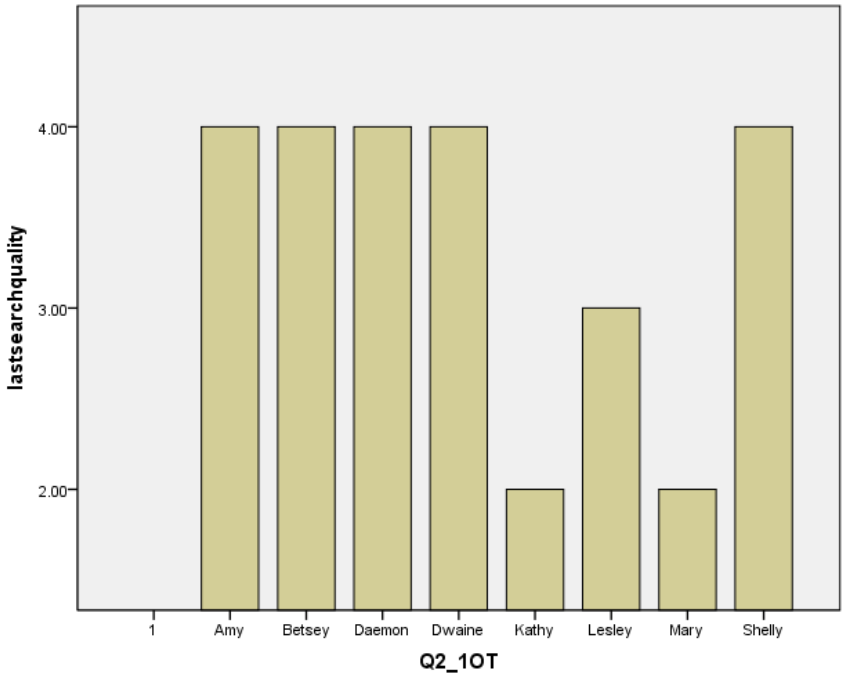

Figure 19. Participants' first search rating for quality of the response

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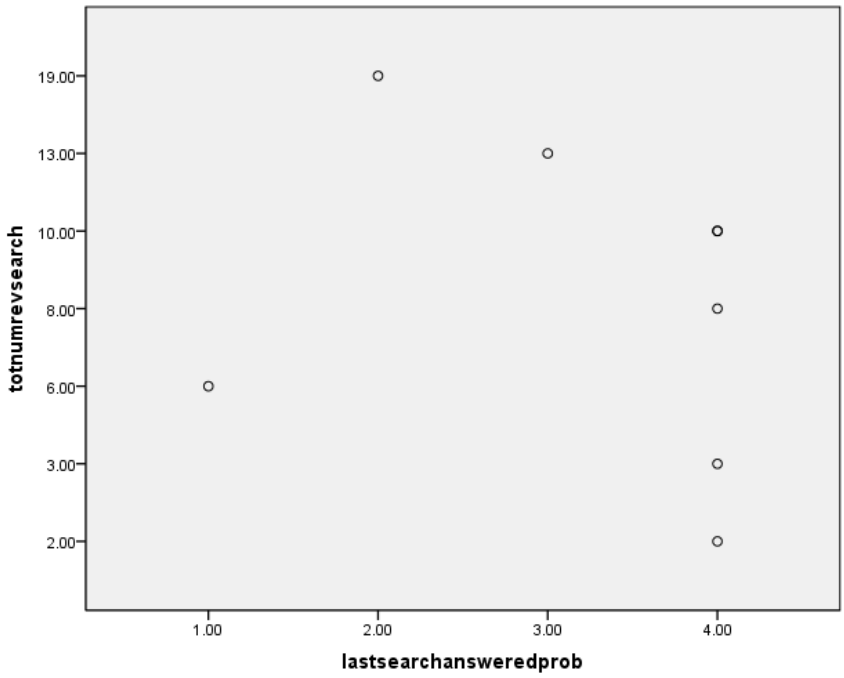

Figure 20. The inverse relationship between the number of revised searches and the ability of the search to answer the problem for some participants.

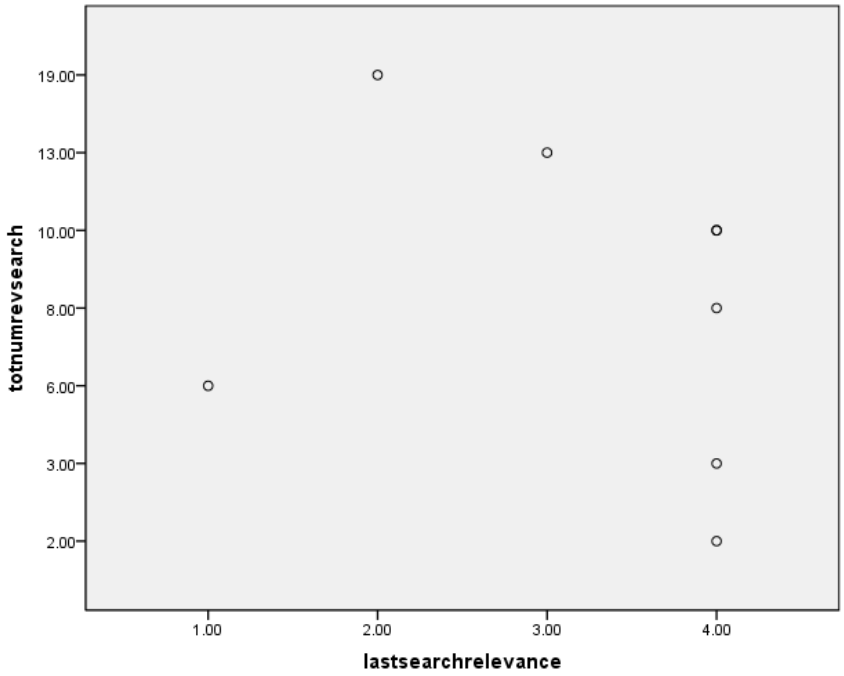

Figure 21. The inverse relationship between the number of revised searches and the relevance of the last search for some participants.

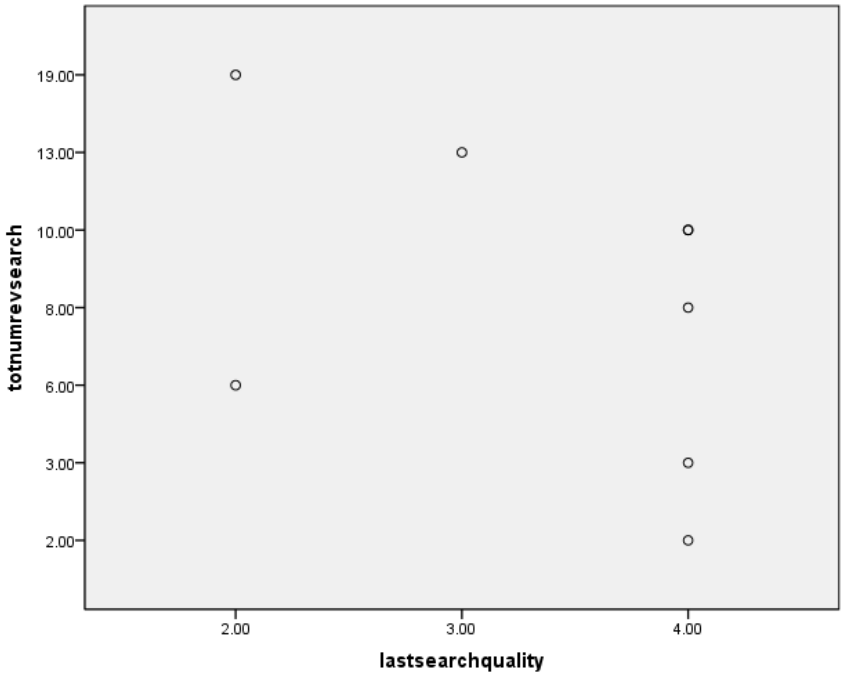

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Figure 22. The inverse relationship between the number of revised searches and the quality of the response of the last search for some participants.

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