

The Nature and Impact of Task Definition:
Information Problem Categorization During Task Definition Within the Information Problem-
Solving Process

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Abstract

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Information literacy describes expertise in information problem-solving. This expertise includes facility in several endeavors addressed by the information behavior literature, including information needs, seeking, and use. Definitions and descriptions of information literacy suggest that this expertise is broadly applicable to a variety of information problems in a variety of content domains. In the library and information science literature, there is scant coverage of the information problem-solving experts, how they think, or whether this expert thinking is transferable to new situations and new contexts. The literature of cognate fields suggests that experts in a variety of domains are more effective in solving problems within their domain than novices because they are more successful in the initial stage of the process, where problem situations are categorized according to those successfully resolved in past experiences. This research project addresses this gap in the library and information science literature by examining the nature and impact of the initial stage of the information problem-solving process, termed Task Definition by the Big6 approach. More than two hundred participants completed a series of

online triad judgment tasks designed to identify differences in categorical determinations made by experts and novices in the domain of librarianship, the nature and impact of these differences, and whether these differences extend across domains. In a follow-up investigation, thirty participants met with the researcher and were given similar sorting tasks; verbal reporting of their personal constructs was recorded via Kelly's (1955) repertory grid (RepGrid) technique. The findings indicate that training and experience in librarianship produce predictable expert behavior in information problem-solving, that this expertise is appropriately described by the expertise literature of cognate fields, and that the expert thinking of librarians has value in multiple contexts. This research contributes to a conceptual understanding of information literacy by highlighting the crucial stage of Task Definition in the information problem-solving process, expands the current repertoire of methods currently used to investigate human information behavior, and informs the pedagogy of information literacy as practiced in schools, libraries, and work environments.

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Preface

If I had an hour to solve a problem, I'd spend 55 minutes thinking about the problem and 5 minutes thinking about solutions.

— Albert Einstein

Give me six hours to chop down a tree and I will spend the first four sharpening the axe.

— Abraham Lincoln

A problem well-put is half-solved.

— John Dewey

It is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail.

— Abraham Maslow

Source: Goodreads Quotes related to problem-solving: <http://www.goodreads.com/quotes/tag/problem-solving>

1.0 Chapter 1: Introduction of Research

This research is submitted to satisfy the requirements of the dissertation degree of the Graduate School of the University of Washington. This dissertation describes the motivation and justification for studying the research problem. It also provides a review of the literature related to this research problem, an explanation of the theoretical framework providing a lens through which it was examined, and a description of the methodology appropriate for this research.

Within the field of library and information science, the study of human information behavior is concerned with information needs, seeking, search, use, and sharing. Information literacy is an area of research focused on effective behaviors in each of these areas and may be operationalized as the skills and stages of the information problem-solving process. The value of information literacy has been established in scholarly literatures, professional practice, pedagogy, and by Presidential Proclamation. Yet, little is known about the cognitive processes involved in information problem-solving.

Investigations in cognate fields examining problem-solving strategies for well-structured problems reveal that domain experts are more successful problem-solvers than domain novices because their knowledge is structured differently. Domain experts more accurately define the task or problem at hand, and are more efficient and effective in solving it. Specifically, in contrast to novices, domain experts typically categorize problems based upon deeper structural features of problems rather than surface features. Information problems, however, are typically ill-defined and ill-structured, with solutions requiring the selection, access, evaluation, synthesis, and use of various types of information from a variety of sources and channels. Task Definition, as described by the Big6 information literacy approach, includes the cognitive processes

involved in defining the problem and identifying information needs. No research has been conducted to date on the problem categorization of expert information problem-solvers.

While research in the cognitive sciences and learning sciences has determined that the domain-specific background knowledge of experts in problem-solving is crucial, the degree to which domain-general problem-solving skills play a role in the successful problem-solving skill of experts remains unclear. Information literacy research is also inconclusive on this point. Yet, definitions and descriptions of information literacy suggest that these skills are domain-general rather than domain-specific; that is, they may be applied successfully from one content domain to another. Another gap in this area of research is the Task Definition of expert information problem-solvers across content domains.

This is a study of information literacy—operationalized as the skills and stages of the information problem-solving process—with a focus on the nature and impact of information problem categorization in the Task Definition stage of the information problem-solving process. The purpose of the study is to inform the knowledge base on cognition during Task Definition in the domain of human information behavior. This study seeks to answer the questions of how information problems are categorized by experts and novices, and whether expertise is transferable across domains. Specifically, this study seeks to determine whether the recognition of surface or deeper structural features in information problem categorization varies as a function of experience within a particular domain. Moreover, this study seeks to determine whether the recognition of surface or deeper structural features in information problem categorization varies as a function of domain knowledge.

Results of this research will contribute to a conceptual and theoretical understanding of information literacy, expand the current repertoire of methods currently used to investigate human information behavior, suggest improvements for the design of information systems and services, and guide pedagogy in developing information literacy skills in schools, work environments, and everyday life.

1.1 Motivation for Research

- *Why is information literacy important?*

Information systems and services are designed to provide the information perceived as necessary to successfully answer questions, accomplish tasks, or solve problems (Gantz et al., 2008). Yet the volume of information available is not necessarily related to success in solving information problems. Rather, success demands that the skills to select, evaluate, and synthesize information from a variety of sources must be mastered in order to meet this goal. In this way, information is turned into knowledge.

The process of successfully using information to accomplish tasks or solve problems, that is, information literacy, is crucial in an information society ("American Library Association Presidential Committee on Information Literacy: Final report," 1989). In October 2009, the Presidential Proclamation of National Information Literacy Awareness Month established information literacy as a national priority (Obama, 2009). Within recent years, the challenge has shifted from seeking and finding information to the use of information to efficiently and effectively solve information problems. Successful solutions to problems personal, societal, and global depend exclusively upon each person's degree of information literacy. In an overview of information literacy instruction, Grassian (2009) states: "In an era when new technologies and

sources of information proliferate at breakneck speed, being information literate is not a luxury or a casual pastime. It is an essential survival skill for a changing world” (p. 2429).

Information literacy may be described as the skills (AASL/AECT, 1998; ACRL, 2008) and stages (Eisenberg & Berkowitz, 1988) of the information problem-solving process. Studies of information literacy from the field of library and information science reveal that the initial stage, Task Definition, is crucial to eventual success in information problem-solving (Brand-Gruwel & Gerjets, 2008; Brand-Gruwel & Wopereis, 2006; Brand-Gruwel, Wopereis, & Vermetten, 2005; Brand-Gruwel, Wopereis, & Walraven, 2009; Head, 2008; Head & Eisenberg, 2009a, 2009b, 2010a, 2010b; Walraven, Brand-Gruwel, & Boshuizen, 2008). Moreover, findings from cognitive science research reveal that the initial stage of the process is crucial for problem-solving success in a variety of domains, including physics (Chi, Feltovich, & Glaser, 1981), mathematics (Chi, Bassok, Lewis, Reimann, & Glaser, 1989), chess (Chase & Simon, 1973; de Groot, 1965), medicine (Lesgold, 1984), and history (Wineburg, 1991, 1998). However, in-depth understanding of the nature and impact of this stage and its relation to information problem-solving success has not been addressed by library and information science research. This research seeks to inform our understanding of this stage of information literacy.

The purpose of this research is to contribute to a deeper understanding of Task Definition within the process of information problem-solving. Two studies will investigate the ways in which we define and mentally represent problems through categories; the first study will investigate the effect of expertise on information problem categorization in a variety of domains, and the second study will investigate the effect of domain knowledge on information problem categorization.

The goals of this investigation include the contribution to the conceptual and theoretical understanding of Task Definition within the information problem-solving process, the adoption

of methods appropriate to an investigation of the research questions, and the development of related strategies for effective pedagogy, information systems, and services.

1.2 Research Problem

- *Does information literacy look like expertise in other domains?*
- *Are information literacy skills generalizable?*

Within the field of library and information science, the domain of human information behavior is concerned with information needs, seeking, search, and use (Wilson 1999). The study of information literacy is concerned with effective behaviors in each of these areas and may be operationalized as the skills and stages of the information problem-solving process. The value of information literacy has been established in scholarly literatures (C. S. Bruce, 1997; Chevillotte, 2010), professional practice (ACRL, 2008; "American Library Association Presidential Committee on Information Literacy: Final report," 1989), pedagogy (Grassian & Kaplowitz, 2009; Julien, 2005), and Presidential Proclamation (Obama, 2009). Yet, what is currently known about the cognitive processes involved in information problem-solving is borrowed from research in the cognitive sciences.

Information problem-solving experiences are critical to the construction of knowledge. These experiences result in the development and modification of the problem solver's existing conceptual framework or schema, or induce a completely new schema. As the problem-solver progresses from novice to expert within a domain, reliance upon broad conceptual frameworks to solve problems shifts to reliance upon specific problem schemas¹. Schemas guide the perception

¹ Anderson (1980) describes schemas as "large, complex units of knowledge that organize much of what we know about general categories of objects, classes of events, and types of people" (p. 128). Jonassen (2011) views schemas as more specific: "a form of knowledge structure used to identify the type of problem being solved" (p. 242). Taken together, these describe the approach taken by the researcher.

of data, the assignment of meaning to information, and the construction of knowledge through understanding. They determine how problems are mentally represented, what new information is perceived as needed, and appropriate solution paths (Sweller, 1988; Talja, Tuominen, & Savolainen, 2005). Categorization occurs during the activation of schema through analogical problem-solving. As stated by Hogan & Rabinowitz (2009), “an important advantage of representing problems on a deep, structural level is that it enables an individual to notice easily that two problems, albeit different in surface characteristics, share solution similarity” (p. 154). These cognitive processes are components of the initial stage of problem-solving, described by the library and information science literature as Task Definition.

Empirical work in information literacy suggests that Task Definition, within the context of the entire information problem-solving process, is crucial to success (Head & Eisenberg, 2009a, 2009b, 2010b; Brand-Gruwel et al, 2005). The Big6 information literacy approach (Eisenberg & Berkowitz, 1990) identifies Task Definition as the initial stage of the process, which includes both the cognitive processes involved in defining the problem, and those involved in identifying information needs. Eisenberg & Berkowitz initially discovered through practice the importance of Task Definition: “How the information problem is initially defined will determine the kinds of solutions or decisions to be considered throughout the process” (2000, p. 16). Scholars in library and information science have developed theories and conceptual frameworks for understanding information needs, but typically these efforts emphasize information seeking, search, and the design of information retrieval systems. Thus, crucial components in the process of solving information problems have been overlooked. The purpose of the study is to delve more deeply into Task Definition; specifically, the nature and impact of information problem categorization within Task Definition.

Literature from the cognitive sciences reveals that domain experts are more successful at solving problems within their domain because they are more effective at the initial phase of the problem-solving process, termed problem representation (Blessing & Ross, 1996; Chi, 2006b; Hardiman, Dufresne, & Mestre, 1989). The knowledge of domain experts is organized differently than that of novices, and is brought to bear more effectively on problem-solving situations than that of domain novices (Bransford, Brown, & Cocking, 2000). Domain experts categorize problems according to type through analogical reasoning, and these types are described by the concept of schema (Novick & Bassok, 2005). Within problem schema is embedded a solution strategy for successful solution to the problem (McNamara, 1994; Novick, 1988). One of the factors that distinguish experts from novices is that experts categorize problems according to underlying structural elements of the problem, whereas novices tend to categorize based upon surface elements of the problem (Chi et al., 1981; Schoenfeld & Herrmann, 1982). The advantage of problem categorization based upon structural features versus surface features is that it enables the matching of successful solution strategies (Novick & Bassok, 2005). As problem-solving experience increases, so too does the reliance on deeper structural features in problem categorization (Niegemann & Paar, 1986). Bransford, Browning & Cocking (2000) recognize the importance of the initial stage of problem representation: “An important aspect of learning is to become fluent at recognizing problem types in particular domains...so that appropriate solutions can be easily retrieved from memory” (p. 44). To date, no research has investigated whether experts in information problem-solving categorize based upon deeper structural features during Task Definition as do experts in other domains.

Another important aspect in understanding information literacy is whether skills may be applied across domains. The transfer of information literacy skills to novel problems and domains is

inherently assumed in the pedagogy of library and information science, but remains untested. Definitions and descriptions of information literacy suggest that these skills are domain-general rather than domain-specific, that is, they may be applied successfully across domains (AASL/AECT, 1998; ACRL, 2008). In 1999, Bates (1999; Pettigrew, Fidel, & Bruce, 2001) proposed that the field of information science is a meta-science—that research and practice in the field is oriented toward the representation and organization of information rather than the knowing of information. This seems to suggest a domain-general skill approach to information literacy. Such an approach is typical in the current scholarly and professional library and information science literature. Although studies conducted by Project Information Literacy find similarities, seemingly in support of the domain-general approach, they also uncover differences between information behaviors in course-related research and everyday life contexts (Head & Eisenberg, 2009a, 2009b, 2010b), seeming to call such an approach into question. Lloyd found evidence of domain-specific information literacy skills in a variety of contexts (Lloyd, 2005, 2007b, 2009; Lloyd & Williamson, 2008), but does not explicitly rule out the possibility of certain skills as domain-general.

The cognitive sciences and the learning sciences host similar longstanding debates. Smith (1991), in proposing a unified theory of problem-solving, recognizes the role of domain-specific knowledge in successful problem-solving, but also identifies general problem-solving knowledge as an important factor. However, research in the cognitive sciences reveals that domain experts are not consistent in their ability to transfer their skills to novel situations and domains (Bernardo, 2001; Didierjean, 2003; Hatano & Oura, 2003; Inagaki, 1986; Mayer, 1998; Mayer & Wittrock, 1996; Novick & Hmelo, 1994). Mayer & Wittrock (1996) characterize the research on the transfer of problem-solving skills as disappointing for this simple reason: “Problem-solving

transfer seems to be rare” (p. 51). While research in the cognitive sciences makes it clear that the domain-specific background knowledge of domain experts is important (Chi, 2006; Bransford, Browning & Cocking, 2000), it is unclear the degree to which domain-general process skills knowledge may play a role in the successful problem-solving skill of experts (Rabinowitz & Hogan, 2008; Smith, 1991).

Further, scholars in the cognitive sciences describe two types of knowledge: declarative knowledge—“knowing that”—that is built upon the learning of content and conceptual frameworks related to a particular domain, and procedural knowledge—“knowing how to”—that is developed through experiences of applying learned domain concepts (Anderson, 2010). In this approach, as experience is gained, the problem-solver relies less on conceptual frameworks and more on schemas developed for each type of problem situation (Mayer, 1983). Studies in neuroscience suggest that these two types of knowledge are located in different regions of the brain (Charness, Milberg, & Alexander, 1988).

Finally, consideration of problem type is necessary to understand cognitive processes during information problem-solving. The types of problems typically used in problem-solving research are well-defined; these lend themselves to the sort of research which can be executed in a laboratory, and variables can be controlled with precision. While well-structured problems achieve the goals of internal validity in empirical research, their employment reduces external validity—findings may not accurately describe how people solve real problems outside of the laboratory. Information problems require that the user access information outside of background knowledge, and are inherently less-than-well-structured, or ill-structured. Numerous studies have found that the cognitive processes brought to bear upon well-defined, or well-structured, problems are different from those engaged in confronting ill-structured ones (Shin, Jonassen, &

McGee, 2003; Schraw, Dunkle, & Bendixen, 1995). Chi (2008) identifies the current lack of and need for research on ill-structured problem-solving behavior in real-world domains (p. 170).

Moreover, Jonassen noted in 2004 that no research existed on how complex, ambiguous, and ill-structured problems affect problem representation (Jonassen, 2004).

This study is an investigation of Task Definition—the initial stage of the information problem-solving process. The cognitive processes involved in defining the information problem and identifying the information needed, which include the mental representation and categorization of the information problem, are components of Task Definition. This empirical study will seek to determine the ways in which we define and mentally represent problems through categories; specifically, the effects of expertise and domain knowledge on categorization. Two studies will seek to answer questions of whether expertise in information problem-solving—that is, information literacy—looks like expertise in other domains, and whether this expertise is generalizable across domains. These investigations will contribute to an understanding of the nature and impact of skills brought to bear upon ill-structured problems, and in turn an understanding of the information problem-solving process. The research questions to be addressed by this study are drawn from this problem space, and dictate the appropriate research approach and strategies for inquiry.

1.3 Research Questions

A review of the literature on information literacy suggests that 1) the way we define a task guides subsequent solution search strategies, 2) the more accurately we define a task, the more efficient and effective we will be in solving them, and 3) general information problem-solving strategies are transferable to novel problems and domains. This research seeks to identify

expertise in information problem-solving, the nature and impact of expert information problem-solving thinking, and the transfer of information problem-solving expertise.

The study was guided by the following overarching research question:

Overarching Research Question: What is the nature and impact of Task Definition in terms of information problem categorization within the information problem-solving process?

The following are the research questions related to this overarching question:

1. How do experts and novices in the domain of librarianship categorize domain-related information problems?

1.1. Specifically, how does the recognition and use of surface or deeper structural features in information problem categorization vary as a function of experience within the domain of librarianship?

1.2. How does the categorization by experts in the domain of librarianship compare to categorization by experts in other domains?

2. How do experts and novices in the domain of librarianship categorize information problems in domains other than librarianship?

2.1. Specifically, does expertise in the domain of librarianship result in the recognition and use of surface or deeper structural features in information problem categorization in novel domains?

2.2. Why does the categorization by experts in the domain of librarianship transfer or fail to transfer to other domains?

1.4 Overview of Methodology

- *Which methods are most appropriate for investigating the research questions and why?*

In cognitive science research, a common approach to studying the performance of experts is to study their performance on contrived tasks, which are tasks not typically undertaken (Chi, 2006b). This approach enables the controlling of task, context, and other variables in a laboratory setting, and enables a comparison to novice performance on the same task. Moreover, the contrived task may be designed to elicit behavior and reflection related to a particular and focused set of cognitive processes, in this case those engaged in Task Definition.

Hoffman (1995) describes types of contrived tasks that have typically been employed in the study of expert knowledge: recall, perceiving, categorizing, and verbal reporting. The triad judgment task is a categorizing task used to highlight differences between domain experts and novices in the way they categorize problems based upon surface or deeper structural features. This method was employed in the domains of engineering (Hardiman et al, 1989), statistics (Rabinowitz & Hogan, 2008), and teaching (Hogan & Rabinowitz, 2009). This method is well-established and well-suited to an examination of Task Definition; more specifically, the categorization of information problems based upon surface or deeper structural features during Task Definition within the process of information problem-solving. Verbal reporting will be employed in the second investigation to elicit the thought processes of participants during a categorization task. These investigations will test the following hypotheses, based upon the research sub-questions:

H1 (RQ 1.1): Experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition.

H2 (RQ 1.2): The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.

H3 (RQ 2.1): Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.

H4 (RQ 2.2): The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains

Investigation 1

The purpose of the first investigation is to examine differences in the way that experts and novices in information problem-solving categorize information problems, in both familiar and novel domains. This investigation tests hypothesis 1 (H1). Hayes (Hayes, 1981) suggests that it takes at least 10 years to accumulate the relevant experience to become a domain expert.

Therefore, experts in information problem-solving will be operationalized as practicing librarians with 10+ years of experience. Participants grouped as either novice or expert in the domain of librarianship will perform a series of domain-related triad judgment tasks online. In the triad judgment task, participants will match one of two source information problems to a target information problem. Experts will be compared to novices, and a quantitative analysis of the data will determine whether the focus on surface or deeper structural features varies as a function of experience within the domain of librarianship.

This investigation will also examine the nature and impact of information literacy knowledge by seeking to answer the question of whether expertise in information problem-solving is generalizable across content domains. One approach suggested by the literature is that the

information literacy skills associated with librarianship constitute domain-general knowledge. According to Fields (2006), “Librarians are usually considered experts in general and sometimes subject-specific information literacy domains. They may or may not be more expert than the student in terms of the primary subject domain, however” (p. 413). Thus, hypothesis 3 (H3) will be tested as well: that experts in information problem-solving recognize the deeper structural features of information problems, even in novel domains.

Participants grouped as either novice or expert in the domain of librarianship will perform a series of triad judgment tasks in two domains novel to the participants—one “near” domain, and one “far” domain (Mayer & Wittrock, 1996). Everyday life situations will serve as the near domain and statistics will serve as the far domain (Bates, 1999). Again, participants grouped as either novice or expert in the domain of librarianship will perform a series of triad judgment tasks, in this series non-domain-related. Experts will be compared to novices, and a quantitative analysis of the data will determine whether expertise in the domain of librarianship offers any benefit in the focus on surface or deeper structural features in the categorization of non-domain information problems. In other words, while all participants may be characterized as novices in these two novel domains, differences in categorization between librarianship novices and experts will be examined.

Investigation 2

The purpose of the second investigation is to examine participant thought processes during a sorting task to determine whether these processes differ from those of experts in other domains, such as mathematics, physics, and chess, and whether these processes confirm the domain-general nature of information problem-solving skills as suggested by the literature. This

investigation tests hypotheses 2 and 4. Participants recruited from Investigation 1 will be asked to complete a sorting task in a laboratory setting with the researcher, according to the protocol of the Repertory Grid (RepGrid) Technique (George Kelly, 1955). Rather than selecting a source information problem to pair with a target information problem, as in the triad judgment task, participants will be presented three information problems and asked to pair two of the three. The participant will then be asked to describe how two of the three are similar, and how the pair is different from the third. In the first round, all information problems will be related to the domain of librarianship; in the second, all will be related to the domains of everyday life situations and statistics. Participant responses will be recorded in note form, and then entered on the RepGrid form when the researcher has determined a clear and concise construct. The participant then sorts all of the information problems into piles of whether they would fall at the positive or negative end of the continuum. Finally, the participant is asked to give a precise rating for each of the information problems on a 5-point scale..

A qualitative analysis will be performed on the RepGrid data. Participants grouped as expert in the domain of librarianship will be compared to novices to determine why the focus on surface or deeper structural features varies as a function of experience within the domain of librarianship, and why information problem-solving skills transfers, or fails to transfer, to novel domains.

Ultimately, these investigations will deepen our understanding of information literacy. The goal of these investigations is to examine the nature and impact of successful information problem-solving; this will be accomplished by investigating the effects of domain expertise in information problem-solving and the transfer of this expertise to novel domains. This research will make theoretical, methodological, and practical contributions to the field of library and information science. The anticipated contributions include informing a multidisciplinary conceptual and

theoretical understanding of Task Definition and its relation to successful information problem-solving, adopting methods atypical of human information behavior research but appropriate to an investigation of the research problem, and guiding the development of effective pedagogy, information systems, and services for the promotion of information literacy and subsequent improvement of information problem-solving.

1.5 Research Justification

- *What does the literature say about information literacy, that is, expertise in information problem-solving? Where are the gaps in the literature?*
- *What does the literature say about problem-solving expertise in other domains? Are these skills transferable?*

The justification for this research was drawn from the literatures of library and information science, the cognitive sciences, and the learning sciences.

1.5.1 Information Literacy: Focusing on Task Definition

Within information science, the study of human information behavior examines “the totality of human behavior in relation to sources and channels of information” (Wilson, 2000, p. 49).

Within this domain, information literacy occupies a unique space by examining expertise in the entire suite of information behaviors, that is, all stages of the information problem-solving process. It is necessary to examine the process through this holistic lens in order to identify the crucial stages and skills that lead to success or failure in information problem-solving. In their study of information literacy in young adults, Head & Eisenberg (2009a, 2009b, 2010a, 2010b) found that college students experienced difficulty at the initial stage of the research process, identified as Task Definition by the Big6 information literacy approach (Eisenberg & Berkowitz,

1990). Teenagers, in particular, experience difficulty at the initial phase of information problem-solving (Walraven et al., 2008). Brand-Gruwel et al (2005) found a significant difference between experts and novices in information problem-solving—experts will take more time defining the problem at the beginning of the process and activate prior knowledge more often than novices. The comprehensive approach employed in these and other information literacy studies has enabled the identification of Task Definition as crucial to successful information problem-solving. To date, no study has focused squarely on this crucial stage within the field of library and information science.

As described by the Big6 information literacy approach, Task Definition is composed of two sub-stages; in the first sub-stage, the problem is identified, and in the second, the information needed to solve the problem is identified. The body of knowledge that has initiated an investigation of Task Definition within the field is the study of information needs. Scholars within the field have made significant contributions to our understanding of information needs; namely, Taylor's levels of need (1968), Dervin's Sense-making (1992), and the anomalous state of knowledge (ASK) approach by Belkin, Oddy & Brooks (1982). These and other scholars have developed theories and conceptual frameworks for understanding information needs, but typically these efforts emphasize information seeking, search, and the design of information retrieval systems. The recognition and assessment of an information need are largely cognitive processes, and methods designed to examine cognition have yet to be employed consistently within the field of library and information science. Wilson (2006) noted this in his seminal paper, originally published in 1981: "If we date user studies from 1948 and the Royal Society Scientific Information Conference (Royal Society, 1948), with its several surveys of users' information-seeking behaviour, then the progress towards some theoretical understanding of the concept of

‘information need’ has been slow...the reason lies in inadequate methodology and the failure to do research that is ‘cumulative’” (pp. 660-661). Case (2002) confirmed this state of information needs research twenty years later, finding that few library and information science scholars choose to delve into the meaning and nature of an information need: “Rather, most writers assume that information needs exist and that they are relatively unproblematic” (p. 67). While the investigation of information needs is far from complete, any investigation of problem identification within the field has yet to begin.

This research addresses the gap in the literatures of information literacy and information needs. The cognitive processes that are components of Task Definition will be the focus of this research. Thus, the strategies for inquiry will be drawn from the literatures of the cognitive sciences and the learning sciences.

1.5.2 Information Literacy: Transfer of Knowledge

Profiles of information literacy describe proficiency in the skills and stages of the information problem-solving process (AASL/AECT, 1998; ACRL, 2008). Information literacy may thus be characterized as expertise in information problem-solving. The study of expertise and expert performance from the literatures of the cognitive sciences and the learning sciences provides insight into the reasons for successful problem-solving in a variety of domains.

Experts are better problem solvers than novices within a domain because of the way that their knowledge is structured (Bransford, 2007). They are more effective in engaging prior knowledge (Mayer, 1983), they categorize problems according to deeper structural features (Chi et al., 1981) through analogical reasoning (Novick, 1988), and they have complex and sophisticated schemas that suggest successful solution strategies (Jonassen, 2011). According to Chi et al (1981):

“...some evidence already exists in the literature to suggest that solvers represent problems by category and that these categories may direct problem solving.” (p. 123). Bransford et al (2000) recognize the importance of problem categorization in that solutions are already embedded within categories, or schema: “An important aspect of learning is to become fluent at recognizing problem types in particular domains...so that appropriate solutions can be easily retrieved from memory” (p. 44). Experts focus on deeper structures of problems in determining whether two problems could be solved similarly (Chi et al., 1981; Hardiman et al., 1989; Hogan & Rabinowitz, 2009; Rabinowitz & Hogan, 2008), whereas novices tend to categorize based on surface features as primary factor in determining similarity. Moreover, novices relate detailed information in describing their approach to problem-solving, whereas experts relate general principles (Chi et al., 1981). As problem-solving skills develop, though, reliance on deeper structures increases (Niegemann & Paar, 1986). To date, no studies within the field have investigated whether expertise in information problem-solving resembles expertise in other domains.

Theories of learning and of knowledge construction guided the strategies for inquiry in this research. Learning in a novel domain typically begins with content and conceptual frameworks—the development of declarative knowledge; problem-solving at the domain novice stage is characterized by reliance upon these conceptual frameworks. Problem-solving based upon surface problem features is typical in the early stages of learning in a new domain. As problem-solving experiences within the domain increase, and the learner recognizes how to apply declarative knowledge in numerous learning experiences, schemas for problem types are induced. This process characterizes the construction of procedural knowledge. Problem-solving in these later stages is typically marked by reliance on schemas and the deeper structural features

of problems (Jonassen, 2011). Schemas are induced by underlying abstract principles in problems; thus, the schema is akin to a category of problems sharing similar abstract principles, whereas specific problems are akin to analogs of each category (Gick & Holyoak, 1983).

Transfer describes the process of applying prior experience to a novel situation (Mayer & Wittrock, 1996). Research on expertise and expert performance suggests that experts tend to use domain-specific strategies to solve problems, that is, strategies unique to a particular domain, rather than domain-general strategies--heuristics that can be applied across a variety of domain (Chi, Glaser & Farr, 1988). For this reason, domain experts are not consistent in their ability to transfer their problem-solving skills to novel problems and domains (Bernardo, 2001; Didierjean, 2003; Hatano & Oura, 2003; Inagaki, 1986; Mayer, 1998; Mayer & Wittrock, 1996; Novick & Hmelo, 1994).

Some have argued, however, that the field of library and information science is a meta-science, oriented toward the representation and organization of information within every domain rather than knowing the domain information (Bates, 1999; Pettigrew et al., 2001). Perhaps, for experts in information problem-solving, a greater proportion of their domain knowledge may be characterized as domain-general when compared to that of experts in other content-oriented domains such as mathematics, physics, and chess. The uncertainty over the domain-generality of information literacy skills remains as a gap in the literature; this research seeks to address this gap.

1.6 Anticipated Contributions

It is anticipated that this research will make theoretical, methodological, and practical contributions to the field of library and information science in the following ways:

Theoretical

- Provide a more accurate and comprehensive description of the nature and impact of categorization in Task Definition during the information problem-solving process than is currently available, and inform our current understanding of information literacy.
- Apply theories from the cognitive sciences and the learning sciences to a library and information science investigation; specifically, structure-mapping theory, analogical reasoning, and Cognitive Load Theory.
- Relate the literature on expertise and expert performance to information literacy as expertise in information problem-solving.
- Examine the assumption of information literacy skills as domain-general.

Methodological

- Expand the current repertoire of methods used to investigate human information behavior.
- Evaluate the operationalization of key concepts for empirical research; specifically, information problems, domain knowledge, and expertise in information problem-solving.

Practical

- Guide pedagogy in information literacy instruction in multiple environments by refocusing on Task Definition.
- Identify research-based strategies for developing Task Definition skill, including worked examples (Atkinson, Derry, Renkl, & Wortham, 2000), kinesthetic representation (Catrambone, Craig, & Nersessian, 2006), case-based learning (Jonassen, 2011), storytelling (Klein, 1998), and multiple analogs (Gick & Holyoak, 1983).

- Examine the assumption of domain-specific information literacy skills as manifest in educational content standards, including the Common Core State Standards.
- Improve the performance of information systems and services by aligning goals with user's state of Task Definition.

1.7 Limitations of Scope

In order to delineate the problem space more clearly, certain limitations to the scope of this research must be delineated:

- **Origins of information needs:** The sources of an information need; that is, the environmental stimuli that trigger gaps in understanding, are useful for framing the problem space, but are beyond the scope of the study. For a further discussion on the origins of information needs, see Cole (2012).
- **Contents of schema:** The concept of schema, that is, the mental representation of an information problem, is central to this research; however, the nature and contents of schemas are beyond its scope. Frame theory provides a description of the contents of schema (Minsky, 1975). For further discussion of schema induction, see Gick & Holyoak (1983).
- **Non-problematic situations:** There are situations in which there is no trigger for a problematic situation; typically, these will be situations in which there is an effort to improve efficiency, as in management organizations; that is, there is no apparent problem, but a careful investigation will uncover situations that become problematic (Mayer, 1983). Another is the situation in which a problem is encountered, but it is not considered to have a social, cultural, or intellectual value to the problem-solver, and so is

ignored (Jonassen, 2011). While interesting, these factors are not the focus of this research.

- Affective and motivational dimensions: Some researchers have examined the effects of affective and conative, or motivational, dimensions in predicting differences between experts and novices (Ackerman & Beier, 2006). However, they will not be considered here.

1.8 Summary

By Presidential Proclamation, October 2009 was declared National Information Literacy Awareness Month to highlight “the need for all Americans to be adept in the skills necessary to effectively navigate the Information Age” (Obama, 2009). Successful information problem-solving is the indicator for information literacy, yet there has been little research to better understand the specific stages of the information problem-solving process.

The study of human information behavior within the field of library and information science is concerned with information problem-solving. The literature on information needs has addressed the initial phase of the information problem-solving process, but assumes that information needs lead directly to information seeking behaviors. The study of information literacy is concerned with successful information problem-solving, and reveals processes in between information need and information seeking behaviors that are crucial to success—namely, Task Definition.

As determined by the cognitive sciences and learning sciences literature, domain experts are successful problem-solvers. Domain experts are more effective than novices in engaging prior experience and knowledge through problem categorization during the initial phase of the problem-solving process. Categorization allows for the transfer of knowledge from base to target

through analogical reasoning and structure-mapping. The concept of schema is used to explain how knowledge may be transferred through the mapping of a current problem situation to a schema for that problem type in memory, and then making inferences and predictions about it—schema is the foundation of a conceptualization of problem representation.

The ability to successfully answer questions, complete tasks, or solve problems requiring information seeking, search, use, or sharing behaviors is a common description of information literacy. Yet little is known about who are the information problem-solving experts, how they think, or whether this expert thinking is transferable to new situations and new contexts.

Literature from the cognitive sciences, the learning sciences, and library and information science indicates that skill in Task Definition is crucial to information problem-solving success.

However, library and information science scholars have yet to apply corresponding theoretical insights to an empirical study of this proposition.

This study examines the way that information problems are categorized during Task Definition by expert and novice information problem-solvers, and the transferability of information problem-solving skills to novel domains. A better understanding of the nature and impact of categorization, and its relation to successful information problem-solving, will inform our understanding of Task Definition within the information problem-solving process in particular, and information literacy in general. In addition to theoretical contributions, this research will make methodological and practical contributions to the study of human information behavior.

2.0 Chapter 2: Review of Relevant Literature and Theoretical Framework

The purpose of this research is to inform the knowledge base on information literacy in the domain of human information behavior. This research examines the nature and impact of Task Definition within the information problem-solving process. Specifically, this research seeks to determine differences in how information problems are mentally represented and categorized by expert and novice information problem-solvers.

This chapter examines the theories, models, and research that contribute to the identification and investigation of the problem space, and guide the research design of the study.

Section 2.1 reviews the historical development of human information behavior research, and then examines the literature on information needs, and serves as historical context for research in the field of library and information science focused on the initial stage of the information problem-solving process.

Section 2.2 examines the literature on information literacy, which provides theory and models for the framework that guided the design of the study. Moreover, this section describes how a process approach to the investigation of information literacy reveals particular stages within the process that warrant further research.

Section 2.3 examines the literature from the cognitive sciences related to problem-solving. This literature also provides theory and models that complete the guiding framework.

Section 2.4 explains operationalizing the concepts of information problem, domain knowledge, and expertise in information problem-solving. These concepts provided guidance in the development of research tools.

2.1 Information Needs: Research & Theory

The problem space serving as the focus of the study is revealed by the study of information needs. This section chronicles the historical development of the study of information needs within the field of library and information science, and then reviews the contributions of Taylor (1968); Dervin (1992); and Belkin, Oddy & Brooks (1982) to the information needs literature.

The work of these scholars identifies a problem space that will be the focus of the study.

Moreover, this review reveals that scant empirical research has been conducted in this problem space in recent years.

2.1.1 Historical Development of Human Information Behavior Research

For this study, human information behavior will be defined by Pettigrew et al (2001): “the study of how people need, seek, give, and use information in different contexts, including the workplace and everyday living” (p.44). Wilson (2000) offers definitions of related terms within the domain that will be used: information seeking behavior describes behavior motivated by a need to seek information for the purpose of satisfying some goal, information searching behavior describes interaction behaviors with information systems (including information retrieval), and information use behavior describes “physical and mental acts involved in incorporating the information found into the person’s existing knowledge base” (p.50)

Wilson (1999) proposes that the origin of research on human information behavior may be traced to the Royal Society Scientific Information Conference of 1948. In the ensuing years, an avalanche of papers and reports on information needs and seeking behavior had been issued, but there is little evidence of efforts to build upon prior research and develop models and theories. Case (2002) characterizes early research on human information behavior as “user studies,” but actually, these focused on the artifacts and venues of formal information systems. By the 1970s,

research began to focus squarely on the user; an important review that serves as a landmark for the shift in focus of library and information science research from artifacts and systems to the user was issued by Dervin & Nilan (1986).

Motivated by calls for conceptual development within the literature to that point, Dervin & Nilan noted that research had not informed practice, and that a paradigm shift in the way information needs and uses were conceptualized was in order. The underlying assumptions guiding research were viewed by many in the literature as limiting the development and maturation of the field. The shift of focus within the field upon the user rather than on the system is credited for the development of alternative approaches to conceptual and empirical efforts. Prominent in Dervin & Nilan's review are the approaches by Taylor (the value-added approach), Dervin (the Sense-making approach), and Belkin, Oddy & Brooks (the anomalous states of knowledge approach). Eventually, the development and maturation of numerous models and theories of human information behavior, and the application and testing of rigorous methods, have contributed to the recognition of the domain (Wilson, 1999). However, at this stage, the domain of human information behavior could reasonably be considered emergent. It is interesting to note that the predominant approaches at this stage are focused on the impetus for information seeking, search, and use behaviors—information needs.

Since the publication of Dervin & Nilan's review, the development of human information behavior as a domain has been chronicled, analyzed, and criticized by a number of subsequent reviews. The landmark review by Pettigrew, Fidel & Bruce (2001) begins with the paradigm shift in information needs and uses research described by Dervin & Nilan (1986), cites progress in a consensus on definitional terms, and traces the progression of user-centered research approaches in three categories: cognitive, social, and multifaceted. This review identifies a

definition for information behavior as “the study of how people need, seek, give, and use information in different contexts, including the workplace and everyday living” (p. 44), and cites Wilson (1999) in recognizing information seeking, information search, and information use behaviors as sub-categories. Limited progress had been made, according to the authors, in answering the challenge of Dervin & Nilan to apply social science theories, develop new theories, and improve the predictive value of theory (p. 3). The review then chronicles the progress made by cognitive approaches to the study of information behavior. This approach focuses on the individual’s thought processes, and is heavily influenced by the information processing approach which had dominated problem-solving research in the cognitive sciences at the time (Newell & Simon, 1972). The cognitive viewpoint is based on the mental processes of individuals, but excluded the social contexts in which human concepts are shaped (Hjorland, 1998).

Kuhlthau’s (1991) information search process (ISP) is cited as an example of this approach; Pettigrew et al note the contribution of this work in explicating the attributes of the individual at each stage of the process, albeit independent of context. Moreover, it confirms that human information behavior “is a process or set of processes or stages that an individual moves through in space and time and that there are reliable methods for mapping these processes and observing the variations and consistent patterns of behavior that emerge” (p. 54). Thus, a distinct and developing theoretical body had become evident within the domain of information behavior, built upon the increasing application of rigorous methods to empirical research, and linked to practice. The review by Pettigrew et al concludes with a call for guidance in the design of information systems that are responsive to user attributes, and to “continue to enhance existing

frameworks and derive new ones that account for emerging concepts” (p. 68). This review also tacitly marks the receding focus on information needs within the literature.

Julien (2000; 2011), in her longitudinal studies of human information behavior literature, notes three themes over the last two decades. The first theme is the consistent application of particular methods within human information behavior research; that is, survey methods such as questionnaires and interviews. The next is an apparent lack of theory development, despite numerous calls (Fisher, Erdelez, & McKechnie, 2005; Pettigrew & McKechnie, 2001). Third, that interest in the type of user group has remained constant; that is, students, scholars, and professionals, although there were signs of interest in those engaged in everyday life information behaviors. Other patterns within the domain were noted: 1) library and information science researchers tend to focus on empirical research and publish in scholarly journals to a greater degree than practitioners; 2) practitioners have less interest in theory or in empirical research, and demonstrate less interest in studies outside of library and information science, indicating that there is a broadening gap between scholarly publication and practice in the field; and 3) the interdisciplinarity of human information behavior research: “This suggests a maturing field and may encourage scholars in the area to expand their explorations of literature outside LIS for relevant work and theory” (p.23). These patterns were corroborated by Fisher & Julien’s (2009) review of the literature, adding the need to integrate human information behavior knowledge into the design of information systems. After decades of contributions to the literature, the questions of why earlier efforts in the area of information needs by scholars to do just that, and to guide the research agenda, remain.

2.1.2 Information Needs

The study of information needs is an area within human information behavior closely situated to the problem space addressed by the study. Dervin & Nilan (1986) cited the various yet similar definitions of information needs at the time of their landmark review:

“Information needs” are similarly defined: 1) a conceptual incongruity in which the person’s cognitive structure is not adequate to a task (FORD); 2) when a person recognizes something wrong in his or her state of knowledge and wishes to resolve the anomaly (BELKIN, 1978); 3) when the current state of possessed knowledge is less than needed (KRIKELAS); 4) when internal sense runs out (DERVIN, 1977; 1980); and 5) when there is insufficient knowledge to cope with voids, uncertainty, or conflict in a knowledge area (HORNE). (p. 17)

In each of these definitions, there is a distinct need for information not already in the user’s background knowledge, be it a “gap,” “anomaly,” “incongruity,” “uncertainty,” or the like. This feature sets this problem space apart from problem-solving research endeavors in other fields.

Library and information science scholars have examined information needs, but typically with aims of informing either the study of information seeking or information search. In his comprehensive survey of research on human information behavior, Case (2002) finds that few library and information science scholars choose to delve into the meaning and nature of an information need: “Rather, most writers assume that information needs exist and that they are relatively unproblematic” (p. 67). However, he found that when library and information science researchers do engage in a discussion of information needs, they typically turn to the work of Taylor; Dervin; and Belkin, Oddy & Brooks.

Levels of Need by Taylor

Taylor (1962, 1968) developed a conception of information needs experienced by the user of library and information systems. Taylor's focus was the negotiation of a question posed to an information system, either through a reference librarian as a human intermediary, or directly to an information system in a self-help situation, and his goal was to inform the discipline of information search. Taylor identified levels of need as a process of cognitive states and corresponding communication strategies: the visceral need proceeds to the conscious need, the formalized need, and, finally, to the compromised need (Taylor, 1968, p. 182). His description of the conscious need comes close to the concept of Task Definition in the Big6 information literacy approach: "At the second level there is a conscious mental description of an ill-defined area of indecision" (p. 182). Unfortunately, he does not speculate on ways in which the user may mentally represent the situation of need based upon prior experience.

Taylor's work is relevant to this review in the following ways: "A perception of need may differ greatly from its ultimate expression in words. There may be 'unconscious needs.' Recognition of uncertainty does not always lead to action. And central to the entire process is the ability to communicate one's thoughts, to 'negotiate' questions and answers" (Case, 2002, p. 68). Taylor's attention to improving the performance of intermediaries within information systems could be conceived as an effort to enhance Task Definition skill. This seminal work by Taylor is useful in examining the cognitive states of the information user, and in identifying the stage in which the user likely engages the cognitive processes involved in Task Definition.

Sense-Making by Dervin

In what Case describes as the “most ambitious attempt to explain the origins of information needs” (2002, p. 70), Dervin (1992, 1998) has developed Sense-making to define information needs as motivation to make sense of a situation in which the individual experiences a gap in an understanding of the world. Dervin’s description of moments in time-space when the individual is making sense of his or her world serves well as a constructivist approach to the concept of Task Definition: “It is assumed that the individual constructs ideas of these moments, that these constructions are themselves strategies, that these constructions are sometimes repetitions of ideas used in the past and sometimes newly created because of how the individual defines the new situation” (1992, p.66). Moreover, Dervin seems to describe the process of mentally representing a problem: “What is proposed here is the idea that the essence of the communicating moment is best addressed by focusing on how the actor in the moment defined that moment and attempted to bridge that moment when conceptualized in gap terms” (1992, p.66). Finally, it links the individual’s perception of the situation to subsequent information seeking behavior: “This formulation leads to a proposition which states that individual use of information and information systems is responsive to situational conditions as defined by that individual. In essence, the individual defines and attempts to bridge discontinuities or gaps” (1992, p. 66). The conceptual underpinnings of knowledge construction, mental representation of problems, and the link to information seeking behaviors are integral to the theory of Sense-making.

Dervin’s work serves well to explain the cognitive states of the information user through the process of Sense-making. However, the focus of Sense-making is information seeking—the information user moves from recognition of a gap in understanding to information seeking; that is, engagement with information sources and systems. In other words, rather than maintain focus

on knowledge constructions of moments in time-space, and the embedded and acknowledged gaps requiring new information which then guide the ensuing process of Sense-making, Dervin's work shifts focus on the search for a solution path through various information seeking strategies.

Anomalous States of Knowledge by Belkin, Oddy & Brooks

The work of Belkin and colleagues (Belkin et al., 1982; Belkin & Vickery, 1985) approaches the concept of information needs as a reduction in uncertainty, which bears a relationship to the work of both Dervin and Taylor. The literature on information needs offers multiple perspectives on the user's initial recognition of an information problem, or the need for information in order to arrive at a perceived goal state. The anomalous states of knowledge (ASK) hypothesis proposed by Belkin, Oddy & Brooks (1982) is firmly grounded in the cognitive viewpoint, and describes the user's interaction with a communication system in moving from a problematic situation in the user's image of the world to a resolution state. The ASK studies of Belkin et al mark efforts within library and information science research to examine the user's problem structure, or schema, and to operationalize it for the purpose of improving information retrieval systems. Yet the focus of this work was to investigate the internal conceptions of problematic situations, and then to recreate them externally for the purpose of informing system design. Once again, the seminal work of these scholars serves to highlight a problem space that remains to be investigated.

The contributions of these scholars have highlighted the importance of information needs as crucial to an understanding of human information behavior, yet there is a lack of empirical research a particular area—the point in which the information user engages in Task Definition.

The study of information needs is concerned with the information seeking behaviors that result, whereas the study of Task Definition is concerned with the strategies that are determined throughout the entire process of information problem-solving. As addressed in the next section, this is the point in which the particular set of solution strategies is determined for the information seeking and search. Much of the literature in the field of library and information science has focused on information seeking behavior. As described by Wilson (2000), information search behavior is a sub-category of information seeking behavior in which the individual is engaging an information system. Moreover, information seeking may or may not always include an identified need, but one imposed upon the individual as in the imposed query (Gross, 1995; Gross & Saxton, 2001). Case concludes that information seeking “is a catchall phrase that encompasses a variety of behaviors seemingly motivated by the recognition of ‘missing’ information” (2002, p.76).

This historical progression has a parallel in the cognitive sciences. If information seeking behavior may be characterized as seeking whatever information will serve to cross the gap, answer the question, make the decision, or solve the problem, and it is often necessary to attempt many strategies in order to move from the initial state to the goal state, then it may be useful to view information seeking behavior as solution search, a term employed in the cognitive sciences to describe the latter stage of problem-solving (after problem representation). Newell & Simon (1972) described solution search behaviors in the information processing approach to problem-solving predominant in cognitive science research in the 1970's. Since that time, however, the limitations of this approach have been revealed, and current approaches recognize the initial stage of problem representation as crucial to problem-solving success. As yet, there has been no such shift within the study of human information behavior.

A comprehensive view of human information behavior, one afforded by a process approach as exemplified by Kuhlthau's Information Search Process (1991) and Eisenberg & Berkowitz' Big6 (1990), exposes the gap between a recognition of an information need and the employment of an information search strategy. The next section will adopt such a comprehensive view in describing a conceptualization of successful information behaviors; that is, information literacy. Such a conceptualization provides a framework integrating relevant concepts and theories for the study, and offers guidance in suggesting a method for investigating the problem space.

2.2 Information Literacy: Research & Theory

For the purpose of this study, information literacy will be operationalized as successful information problem-solving behavior. In turn, successful information problem-solving is an indicator of information literacy. This section chronicles the historical development of information literacy within the domain of human information behavior, describes models of information problem-solving, and establishes a conceptual and theoretical framework serving as the lens through which the problem space will be examined.

2.2.1 Historical Development of the Study of Information Literacy

Information literacy as an area of study is rooted in the study of human information behavior. In his address to the Information Industry Association as president in 1974, Zurkowski's definition of information literacy as "an individual's capacity to use information tools and primary sources to address problems" marks the earliest attempt to define information literacy (Zurkowski, 1974). The American Library Association recognized the practical and strategic significance of this concept, and established the Presidential Commission on Information Literacy in 1987, with a published report in 1989 ("American Library Association Presidential Committee on Information Literacy: Final report," 1989). This report is significant in that it formally acknowledged the

importance of the concept, and offered a description of information literacy with a corresponding set of skills (Eisenberg, Lowe, & Spitzer, 2004): “To be information literate, a person must be able to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information” (“American Library Association Presidential Committee on Information Literacy: Final report,” 1989, p. 1). The ALA report continues to serve as a foundational document in the information literacy literature (O'Connor, 2009); however, attempts to define information literacy have been numerous.

Defining Information Literacy

The professional literature, concerned with information services and instructional programming, typically describes skillsets of information literate students: able to determine the nature and extent of the information needed; to access needed information effectively and efficiently; to evaluate information and its sources critically and incorporate selected information into their knowledge bases and value systems; to use information effectively to accomplish a specific purpose; to understand many of the economic, legal, and social issues surrounding the use of information; and to access and use information ethically and legally (AASL/AECT, 1998; ACRL, 2008). As described by Webber & Johnston (2000): “A distinctive feature of definitions of information literacy is the tendency to personify it as a set of personal attributes” (p. 382). Thus, generic lists of attributes describing the information literate person are common (AASL, 2007; ACRL, 2008; Doyle, 1992). Criticisms of this approach include the risks associated with decontextualizing information behaviors, and the tendency to teach and assess these skills in isolation.

There is little consensus on a universal set of skills in the professional literature, and conceptions of information literacy frequently change. The American Association of School Librarians (AASL) has recently revised its approach to articulating information literacy, and to guidelines for school library programs (2007). Currently, the AASL contends that multiple literacies are required for navigating the sea of available information and for the tools that access it.

Scholarly attempts to define information literacy are equally numerous, and include that of Bruce (1997), who conceptualizes information literacy as comprising multiple literacies. In summarizing the results of her study of information literacy, Bruce concludes that what is needed is “a way of thinking about information literacy in terms of varying relations between an information user and information. Information literacy has, until now, been considered in terms of attributes of persons, rather than in terms of ways in which people relate to the information” (Bruce, 1997, p. 158). Kapitzke (2003) also cites multiple literacies, and offers the term “hyperliteracy” to address this need. The “hypermediated textualities” described by Kapitzke include messages, blogs, tweets, and posts that are an integral part of the distributed, mediated, and social natures of information flows today.

Lloyd's Information Literacy Landscapes

Lloyd has proposed an approach to defining information literacy, one based on the task, situation, and context (2006). She likens this approach to navigation through a landscape, where information literacy varies with the particular landscape in which it is embedded. This approach is suggested by the framework for the ‘seven pillars’ of information literacy by SCONUL (*Information Skills in Higher Education*, 1999).

Lloyd describes two epistemological approaches to the definition and description of information literacy:

The first emphasizes information literacy from a library-centric approach clearly focusing on skills and abilities and reveals the applied and instrumental nature of information literacy as it is articulated, taught, and practiced within a formal learning context. The second type of definition of information literacy, which has been used more recently, tends to emphasize the learning experience created when an individual engages and uses information. (Lloyd, 2010, p. 41)

Lloyd argues, however, that the first library-centric, formal learning environment approach marginalizes information literacy, relegating it to this realm, with little relevance to the real world (Lloyd, 2010, p. 4). She describes the second as a socio-cultural practice that facilitates knowledge, that information literacy is situated within a contextual environment, with a unique set of information sources, channels, and formats, and is realized through the engagement of social constructs, sensory, and cognitive factors (p. 26). Essentially, that information literacy is context-dependent.

Lloyd's approach does recognize an aspect of information literacy that is at least applicable across a variety of domains: "information literacy occurs within all contexts and acts as a catalyst for learning about context, its practices and processes" (p. 29). Moreover, "in the process of becoming information literate, people undergo a transformation from expert to novice" (p. 30). Lloyd found familiar differences between emergency service novices and experts: for one, experts recognized the value of defining the task at hand and the information needed to address it, and novices did not (2004, 2007).

Certain information literacy scholars suggest that consensus on a definition is in order: Bawden (2001) states that this effort must be a central topic in information science; Cool (2004) and Webber & Johnston (2000) contend that the debate over how best to define information literacy has detracted from the more pressing concern of developing it through pedagogy; Gross (2005) and Oakleaf (2006, 2008) make a case for the need to define information literacy in order to assess competence; and Elmborg (2006) cites the confusion over the definition of information literacy as the source of ambiguity in guiding the future direction of librarianship. Wilder (2005) suggests that educational efforts to understand, promote, and assess information literacy are inadequate.

Tuominen, Savolainen & Talja (2005) cite these efforts to reconcile differing conceptions of information literacy as they relate to a research agenda within the field, and conclude that any approach to define information literacy should consider “the interplay between information technologies, workplace learning, and domain-specific knowledge formation processes” (p.329). The response by Sundin (2008) to the multiple conceptions of information literacy offers an alternative to the debate: “A reflective awareness of different approaches to information literacy is important for both researchers and LIS practitioners” (p. 24). This response serves as a call to shift the emphasis within the information literacy literature from a debate on definition to empirical research.

Information Literacy Research

Although many studies of human information behavior are not concerned with the entire process of information problem-solving, their findings are relevant to an understanding of information literacy. Relevant findings include: undergraduate students inaccurately describe themselves as

information literate (Maughan, 2001; Wilder, 2005), they do not see the need to seek out the most relevant and reliable sources of information (Agosto, 2002; Fidel et al., 1999; Heil, 2005), college faculty had little confidence in students' abilities to determine reliable Web resources (Herring, 2001), younger students are less-than-effective in their search strategies and in their abilities to discern accurate sources in solving their information problems (Agosto, 2002; Large, 2004; Shenton & Dixon, 2004; Valenza, 2007), and issues of gender, age, collaboration and community are critical factors in the success of information-seeking behavior (Agosto, 2004; Agosto & Hughes-Hassell, 2005; Bilal, 2004; Bilal & Kirby, 2002; Dresang, 2005; Fisher & Durrance, 2004; Meyers, Fisher, & Marcoux, 2007, 2009). These studies contribute to our understanding of different stages of information problem-solving, but do not address the question of which stage of the process is critical for successful information problem-solving, nor why.

Rather than focus on one area of human information behavior; for example, information seeking, search, or use, the study of information literacy takes a comprehensive approach to the examination of information behavior that results in successfully completing a task, answering a question, or solving a problem. A process approach such as this enables the identification of particular practices that lead to, or thwart, successful outcomes.

In a series of field studies under the Project Information Literacy research umbrella, Head & Eisenberg provide current insights into the information literacy practices of young adults in higher education (2009a, 2009b, 2010a, 2010b). In the first study, qualitative data from a series of focus groups revealed that students seek context for their course-related and everyday life-related research. Students need context in order to formulate the problem situation and generate a plan for resolution---in short, the information problem is situated within a context that is crucial to recognize. Students claim that context is “the most laborious, yet requisite, part of the research

process” (2009a, p. 5). Moreover, this study found that college students rely upon online pre-search tools such as Wikipedia to develop a better sense of the problem type prior to embarking upon the next stages of research.

A follow-up study, a survey of more than 2,300 students on six campuses across the country, verified descriptions of the four contexts revealed in the initial study. Each of the contexts identified in the new typology involve a number of activities associated with the initial stage of the information problem-solving process—Task Definition. Among them: finding the summary and background of a topic, determining appropriate search terms and defining related terminology, figuring out procedural guidelines, and developing strategies for the research process (Head & Eisenberg, 2009b).

The next study (Head & Eisenberg, 2010b), a survey of more than 8,300 students across the country, found that a vast majority of students report the most difficulty as the initial stage of the research process, including defining their topic, and narrowing it down after initial search; students do not report such difficulty with everyday life-related research, indicating that differences between imposed queries and self-generated ones (Gross, 1995) are significant. While these studies indicate that students are rather savvy with the information systems and services available to them, they still rely on a small and familiar set of resources, a rote method for conducting research activities, and experience difficulty getting started. Moreover, Gross (Gross, 2007; Gross & Latham, 2009) asserts that students overestimate their information literacy skills, possibly because they believe that information seeking and search skills are the keys to successful information problem-solving.

Brand-Gruwel et al (2005) sought to identify the key stages of the information problem-solving process, and adopted an expert-novice analysis to determine these stages. They found that their experts “spend more time than the novices on defining the problem in the beginning of the process. During this phase, the experts also read the task more often and activated their relevant prior knowledge more often than the novices. This is in agreement with the problem-solving literature, which indicates that experts typically pay more attention to the analysis of problems” (p. 502). This finding is corroborated by Land & Greene (2000). Another finding: “The main difference between the experts and the novices is that experts pay frequent attention to the (re)formulation of the problem while this is completely ignored by novices” (p.503).

Walraven, Brand-Gruwel & Boshuizen (2008) sought to understand the difficulties in the information problem-solving experienced by different age groups: children, teenagers, and adults. They conducted a literature review in order to find coverage of this topic in the literature since 1995, using key terms that included “information problem solving” and “information literacy.” Their findings were illuminating, and of direct relevance: they first report that “the skill ‘define information problem’ is rarely included in information problem solving research” (p. 627); they then report that, while several other studies do reference “problem definition,” their focus was on information seeking and search behaviors; they conclude: “it appears that adults do not have trouble with the constituent skill ‘defining the information problem’. Teenagers have trouble with ‘formulating questions’, ‘activating prior knowledge’, ‘clarifying task requirements’ and ‘determining needed info’. Little is known about young children and their problems with this constituent skill, but based on the problems teenagers have, we assume that the same problems occur with younger children” (p. 629).

Brand-Gruwel, Wopereis & Walraven, in their review of the impact of online information seeking on the overall information problem-solving process (2009), found that none of the groups in their study spent a significant amount of time on defining the problem. However, a descriptive analysis of their data reveals that the PhD students and teachers in their study spent more time on this stage than did the students; moreover, the way this behavior was coded may have also contributed to the results, as situations in which subjects reviewed and possibly reformulated their representation of the task was counted in a different category. They also found that the secondary students in their study spent less time on the initial stage of the process overall compared to the higher education students, the teachers, and the PhD students.

Other related studies of students in higher education reveal: a lack of adequate information literacy skills (Maughan, 2001), a struggle with the first stage of the research process (J. E. Larkin & Pines, 2005), and that direct instructional programming is necessary (Boon, Johnston, & Webber, 2007; Johnston & Webber, 2003; Webber & Johnston, 2000). Moreover, faculty members believe information literacy skills are important, but do not provide instruction (Head & Eisenberg, 2010a). Studies by Lloyd (2007a, 2007b, 2009) situated in the workplace reveal highly-situated contexts in which information literacy is embedded within unique informational, social, and situational contexts. Furthermore, Bilal (2001) cites numerous studies indicating that students have difficulty formulating search strategies. Bates (2009), in an overview of information literacy literature concludes: “In sum, people often vastly underutilize available resources and are often quite inefficient in finding what they do find” (p. 2387). Unfortunately, the set of competencies necessary to successfully solve information problems that employers assume that college graduates have mastered is “sorely incomplete” (Head, 2012).

In short, findings indicate that success at the initial stage of the information problem-solving is related to information literacy, and that difficulty at this stage typically leads to inefficient and ineffective information behaviors in later stages of seeking, search, and use.

2.2.2 Information Problem-Solving and the Construction of Knowledge

Constructivism serves well as an epistemological approach for this study. It is compatible with established conceptions of information needs that lead to understanding and knowledge, the outcomes of successful information problem-solving. This section describes information problem-solving models that contribute to the conceptual and theoretical framework underpinning the investigation.

Information Problem-Solving Models and Constructivism

The researcher takes a positivist view of information—that it may be codified and organized. From there, it may be encountered or accessed and used to construct knowledge. Bates (2006) builds upon the work of Norbert Wiener (1961) and defines information as not matter or energy itself, but the pattern of organization of matter and energy. In an overview of the research on information behavior, Bates (2009) highlights the risk of examining information behavior out of context: “People are trying to solve problems in their lives, not ‘seek information.’ Activities that involve information seeking are seldom differentiated from the other actions taken to solve problems. Good research design for the study of information seeking must recognize this reality; asking people what they have done lately in the way of information seeking is therefore not the way to get data with high internal validity, as a rule” (p. 2386). Bates appears to be recognizing what happens during information problem-solving—the transference of information into knowledge during the process of constructivism through experience.

Conceptual models of human information behavior describe information seeking within the context of the information problem-solving process. Wilson (2000) explains that these models are more than simply descriptive, these stage process models are often based on theory and describe behavior patterns that inform a research agenda, and guide the development of information systems, services, and instruction used in practice.

Models of information literate behavior; that is, successful information problem-solving, include Kuhlthau's Information Search Process (2004) and Eisenberg & Berkowitz' Big6 information literacy approach (1990). Several studies have adopted successful information problem-solving models as an operational definition of information literacy. In reviewing the skills necessary for life in an information society, Brand-Gruwel (2005) concludes: "All the skills, knowledge and attitudes, which are needed...can be defined as information literacy...or as information problem-solving" (p. 488). These models provide a framework for organizing the many aspects of information behavior as described by Wilson (1999) and focus for an investigation of information literacy.

Kuhlthau's Information Search Process

Kuhlthau's (1991, 2004) information search process (ISP) describes information seeking behavior through the process of seeking meaning in the face of uncertainty. Kuhlthau depicts this information behavior as a process of constructing knowledge. Throughout the six stages of Initiation, Selection, Exploration, Formulation, Collection, and Presentation, people experience "an interplay of thoughts, feelings, and actions" (Fisher et al., 2005, p. 230). This model was developed within the context of research assignments and reflects the nature of these types of task—imposed (Gross, 1995) and well-structured (Jonassen, 2000).

In her development of the information search process, Kuhlthau borrowed the concept of constructivism and applied it to her investigation of how knowledge is constructed during information seeking and search. When students face uncertainty, she proposes, they move to actively construct an understanding of the world. Kuhlthau's interpretation of constructivism begins with the learning theory of John Dewey. According to Dewey (1910), learning is an active and individual process, and is reinforced through reflection. It is through reflection that we recognize the causality between our actions and their consequences. Reflective thinking is important in successful information problem-solving, and is compatible with constructivist learning environments. As we build a more complete and accurate understanding of the world around us, we are able to transfer this understanding from one situation to another. Kuhlthau highlights Dewey's emphasis on education's key role in a democratic society; she notes the connection to conceptualizations of information literacy that emphasize the need to accommodate change through learning: "Learning how to learn may be understood as individually internalizing a constructivist approach to learning" (Kuhlthau, 2004, p. 15).

Vygotsky's descriptions of the social conditions under which optimal learning occurs (Kozulin, 2003) informs her work as well in the design of instructional programs and the delivery of information services, thus giving her approach an added dimension: social influences upon the construction of knowledge.

Kuhlthau adds to Dewey's philosophical approach to knowledge construction the perspective of Kelly, who offers a psychological dimension to constructivist theory. Kelly's Personal Construct Theory (1963) proposes that experiences generate constructs which organize perceptions into patterns and enable predictions about the way the world works. This system of constructs is highly personal and guides behavior based upon predictions; the restructuring of constructs to

assimilate familiar information and the formulation of new constructs to accommodate new information constitutes learning that occurs throughout life. Prediction is a key concept in Kelly's theory—we make choices in our behavior that reflects our predictions about an outcome. These outcomes will either confirm or disprove our predictions, but either will provide feedback that will alter our constructs and inform future choices. This approach is compatible with an approach to understanding schema, which is a framework of constructs; schemas are continually reformulated with the experience of each new problem situation. Moreover, knowledge is a framework of highly-developed, that is, robust, schemas. One study found that a learner's epistemological beliefs about learning has an impact on learning success; in fact, the constructivist belief was found to contribute to the most effective learning (Tu, Shih, & Tsai, 2008). Constructivist theory, as interpreted by Kuhlthau, serves well this investigation of information literacy. Talja, Touminen & Savolainen (2005) concur: "Instead, humans must "construct" their own knowledge. Individuals build their knowledge through their experiences that enable them to build "mental models" of the world. Mental models consist of schemas, scripts and knowledge structures. These models may change and become more detailed and sophisticated as individuals receive new sensory data or encounter novel situations" (p. 83).

Kuhlthau's work does not examine in depth a particular stage of the ISP. However, Bates (2010) notes the importance of the beginning of the research process in an overview of Kuhlthau's work: "Specifically, she discovered that the combined process of researching and writing a paper is complex and difficult for most people—indeed, the library research is inextricably bound with the understanding and gradual formulation of the thesis of the paper" (p. 2387).

Eisenberg & Berkowitz' Big6 Information Literacy Approach

The Big6 Skills approach to information problem-solving by Eisenberg & Berkowitz (1990) describes the process of successfully solving an information problem. This model describes the first stage as Task Definition, in which the problem solver defines the task or problem to be solved, and then identifies the information needed to solve the problem. From there, the problem solver engages in information seeking strategies, location and access, use of information, synthesis, and evaluation. The process is often not linear, and stages may be repeated throughout the process. Tuominen et al (2005) recount the impact of the Big6 Skills model: “In 1990, Michael Eisenberg and Robert Berkowitz proposed the model of ‘Big Six Skills’ that describes the phases or stages of information seeking and use for the purposes of problem solving. Both ALA’s and Eisenberg and Berkowitz’s characterizations, among others, legitimized and motivated librarians’ efforts in education for IL by defining it as a part of the wider literacy continuum and by coining the concept of lifelong learning” (p. 332).

The development of the Big6 information literacy approach was informed by practice. Studies have used the Big6 information literacy approach as a conceptual framework for the study of information problem-solving (Brand-Gruwel et al., 2005; Brand-Gruwel et al., 2009; Gerjets & Hellenthal-Schorr, 2008). Brand-Gruwel, Wopereis, & Walraven (2005) studied expert and novice higher education students in an effort to decompose the Big6 information literacy approach into cognitive components, and to determine the key components in the information problem-solving process. They found that the Big6 information literacy approach was an accurate description of stages in information problem-solving, and useful in the decomposition of cognitive components into related categories.

While the models described above and numerous others have been proposed to describe information literate behavior within library and information science, more similarities than

differences are evident among them (Eisenberg & Brown, 1992). Each includes an initial stage in which a problem, or task, and corresponding need for information is identified. A process approach to information problem-solving recognizes the associations between stages, and how skills are applied to information problems according to the individual's perception of the problem and their own readiness for addressing the situation. These reveal the important processes involved in the successful information behavior between information need and information seeking behaviors. The Big6 information literacy approach will serve as the model for successful information problem-solving in this study.

Focusing on Task Definition

While the research on information seeking and search typically focuses attention on human information behavior in the middle stages of the process of information problem-solving, process approaches reveal crucial gaps in the literature, Task Definition in particular. According to Eisenberg & Berkowitz (1990): "Most people spend too little time on task definition. The tendency is to push ahead even though they have only a general or vague understanding of what it is they are seeking to accomplish. By spending time considering the information problem and then articulating a clear understanding of (a) the information problem and (b) specific information needs related to that problem, people can move much more efficiently toward solutions" (p.6).

In a description of the information problem-solving approach, Bystrom & Jarvelin (1995) distinguish the stages where information is needed: "In routine problems there is no problem-formulation phase; the inputs, process, and outcomes are a priori known. In difficult problems, these cannot be a priori determined and thus, there are two kinds of information needs: (1)

information needed in problem formulation, and (2) information needed in problem solving” (p.194). In terms of Kuhlthau’s information search process, the stages of initiation, selection, exploration, and formulation are components of the problem-formulation phase, whereas the stages of collection and presentation belong to the solution generation phase. Vakkari (1999) terms the specific information needs related to the problem identified by the problem-solver as “predetermined information requirements,” and finds that it is directly related to the perceived complexity of the problem.

In the cognitive sciences, this stage is termed problem representation. In these disciplines, a number of cognitive components are related to this stage, including problem recognition, activation of prior knowledge, and analogical and causal reasoning (Gick, 1986; Jonassen, 2011; Newell & Simon, 1972). The concept of problem schema is the integration of several of these processes into a framework that enables problem-solving; a schema may be induced for every problem type, and will be unique according to the individual perceptions and characteristics of the problem-solver (Jonassen, 2011).

“Our skill in problem solving depends in a very important way on our store of problem schemas. Each problem schema we know gives a us a very valuable advantage in solving a whole class of problems—an advantage which may consist in knowing what to pay attention to, or how to represent the problem, or how to search for a solution, or all three. Clearly the more schemas we know, the better prepared we are as problem solvers” (Hayes, 1981, p. 8)

Thus, for this study, problem representation is a term that refers to the perception and mental construction of a problem; Task Definition is a term that also refers to these cognitive processes,

but focuses on the accompanying identification of information perceived to be necessary to solve the problem.

While numerous studies within and outside of the field of library and information science identify the initial stage of the information problem-solving process as critical to success, to date no studies have focused squarely on Task Definition—a clear gap in the literature. Moreover, methods for describing, measuring, and manipulating Task Definition behaviors and processes have yet to be tested.

2.2.3 The Gap Revealed by Information Literacy Research

When practical efforts to facilitate information problem-solving through the development of information systems, the provision of information services, and the implementation of instructional programs are ineffective, library and information science research fails to provide conclusive reasons. Information systems and services engaging the user in the middle stages of the process--information seeking and search--are not always effective in an environment where information is readily accessible, and other crucial skills are required. A comprehensive view of human information behavior, as exemplified by the process approaches of Kuhlthau and Eisenberg, reveals stages in the process that have been infrequently addressed by scholars and researchers in the field. It would appear from the dearth of research in this area that information needs lead directly to information seeking behaviors, bypassing important cognitive and behavioral stages essential to solving information problems.

The leap from an information need to information seeking behaviors may be the cause of unsuccessful information problem-solving. Head & Eisenberg (2009a, 2009b) found that students did not rely upon library staff in their course-related and everyday life research

practices, foregoing assistance at the Task Definition and Information Search Strategy stages to proceed directly to information search. Gross (2005) found that students felt very confident in their information seeking and search skills, but erroneously extend that to a perception that they are information literate.

This gap has been the focus of problem-solving research in the cognitive sciences for decades, although the processes involved in problem representation do not include the identification of information perceived as needed to solve the problem, as included in the corresponding concept of Task Definition within the field of library and information science.

The next section reviews the literature related to problem-solving in the cognitive sciences, with an emphasis on problem representation.

2.3 Problem-Solving in the Cognitive Sciences: Research & Theory

A review of the literature from the cognitive sciences, including cognitive psychology, the learning sciences, and expertise and expert performance, reveals themes with parallels in the literature of library and information science. Recall Dervin's (1992) comprehensive framework for describing human information behavior through Sense-making. This approach describes the process of knowledge construction: "As an individual moves through an experience, each moment is potentially a sense-making moment. The essence of that sense-making moment is assumed to be addressed by focusing on how the actor defined and dealt with the situation, the gap, the bridge, and the continuation of the journey after crossing the bridge" (p. 70). Compare this passage to Hayes' (1981) description of problem-solving: "Whenever there is a gap between where you are now and where you want to be, and you don't know how to find a way across that gap, you have a problem. Solving a problem means finding an appropriate way to cross a gap.

The process of finding a solution has two major parts: 1. Representing the gap—that is, understanding the nature of the problem, and 2. Searching for a means to cross it.” (p.1). These represent two perspectives on the same phenomena apparent throughout a review of the two literatures. The patterns of terminologies and conceptualizations from two different fields are not at odds with one another. Rather, these perspectives are complementary, and together suggest a more clearly-defined problem space that will be addressed by this study, and complete the conceptual and theoretical framework.

Two Approaches to Problem-Solving Research in the Cognitive Sciences

As stated in the Hayes passage, there are two distinct phases in the cognitive science problem-solving literature: 1) the initial phase in which a problem is encountered and represented, and 2) the subsequent phase in which a solution is generated and executed. In other words, it has been characterized by two distinct sets of processes: problem understanding processes and solution search processes (Ernst & Newell, 1969; Newell & Simon, 1972). This distinction is a recurrent theme throughout the literature. It marks the historical emphases of problem-solving research and the predominant theoretical approaches of the day, provides a focus for gaps in research, and suggests a parallel distinction between information needs and information seeking in library and information science.

2.3.1 Historical Development of Problem-Solving Research in the Cognitive Sciences

For decades, problem-solving has been the focus of research in the cognitive sciences. A number of scholars make claims of association between problem-solving skill and intelligence. Holyoak (1984) describes “problem-solving skill as a manifestation of intelligence” (p. 225), as does Sternberg (1981): “My version of this view...is that intelligence consists of a set of developed

thinking and learning skills used in academic and everyday problem solving.” These claims support the broader notion that skill in solving problems is the mark of a higher level of cognitive functioning, and offer a rationale for the attention given the study of problem-solving in the cognitive sciences.

Early Approaches to Problem-Solving Research

Early approaches to research on problem-solving can be traced to the early 1900s; the Wurzburg school established itself as the first major school to conduct problem-solving research, but its work was disregarded as a result of its failure to develop useful theories and rigorous methods. In its wake, associationism, which focused on problem-solving behaviors associated with successive behaviors in a chain, and Gestalt theories, which focused on the perception of elements as a whole structure, guided problem-solving research (Mayer, 1983). According to Gestalt psychologists, the goal of problem-solving is a structural understanding of the problem itself. This is accomplished through the process of relating one component of the problem situation to another to comprehend how all the parts fit together in satisfying the requirements of the goal. Gestaltists emphasized the organization of elements into a structure; the key to successful problem-solving from this point of view is reorganization of elements in a new way to solve the problem. This approach is consistent with Gestalt views on perception as the mind’s attempt to impose structure to incoming stimuli. It also aligns well with theories from the field of library and information science that explain how data is perceived and assigned meaning to create information.

A basic tenet of the Gestalt approach is that there are two kinds of thinking: “productive” thinking, or insight, and “reproductive” thinking, or trial and error. These themes are apparent

throughout the progression of psychological problem-solving research. The latter, reproductive problem-solving, is evident in later information processing approaches to problem-solving characterized by the work of Newell & Simon (1972), and the former, productive problem-solving in which the solver discovers the structure of the problem situation, is evident even in recent research efforts. Typical of research comparing these two approaches, Hilgard et al (1953) compared the performances of a participant group that practiced reproductive, or memorizing, strategies to the performance of a participant group practicing productive, or structural understanding. They found that the two groups performed about the same on a one-day retention test, but the reproductive thinking group performed significantly worse on a series of unrelated problems. That the skills practiced by the memorizing group did not transfer to novel situations is characteristic of the dilemma faced by problem-solving researchers even today, termed by some “the transfer problem.”

These types of thinking may help to clarify the processes at work in different problem situations. Well-structured problems will typically require reproductive thinking, in which rote memorization of procedure or algorithms and a minimum amount of structural analysis is required. Ill-structured problems, on the other hand, typically require novel and productive thinking, with a great deal of structural analysis to determine the proper approach. While the cognitive sciences have advanced beyond the Gestalt approach, these concepts are applicable to an understanding of information problem-solving behavior.

Duncker was a Gestalt psychologist who made landmark contributions to our understanding of problem-solving. For one, Duncker developed and employed a think-aloud protocol in his empirical work. Moreover, he introduced two of the most famous tasks within the field: the tumor problem and the candle problem (Duncker, 1935/1945). In the candle problem, Duncker

introduced a series of objects to his subjects: a matchbook, a candle, and a box of tacks. The task was for the subject to attach the candle to the wall using only the given objects. In this experiment, Duncker introduced the concept of functional fixedness: while the solution to the problem was to simply remove the tacks from the box and use them to attach the box to wall to hold the candle, he hypothesized that subjects would have a fixed conception of the box and its useful purpose—to hold tacks. Functional fixedness accounts for the failure of subjects to remove the constraints in their thinking and see the multiple purposes of the box. A later experiment found that introducing the tacks outside of the box removed the fixed notion of the box as a tack holder, and allowed for a higher frequency of successful solutions.

There is a link to later approaches to problem-solving conceptions here: the box serves as a container in the initial phase of the problem-solving process, problem representation, and as a holder in the latter phase, solution generation. However, at the time of Duncker's experiment, Gestaltists were interested in determining whether subjects could reorganize the elements of their thinking into a new structure that could allow for the repurposing of the box. Essentially, the correct solution path was only determined after the elements of the problem were restructured in the initial problem representation phase. Numerous studies on problem-solving suggest that a problem-solver with a fixed problem representation that does not allow for productive thinking, in Gestalt terms, will not find a correct solution (Cooper, 1990; Kotovsky, Hayes, & Simon, 1985). In other words, with a fixed and inaccurate problem representation, a problem cannot be successfully solved, no matter how many solution strategies are implemented. This conception of solution strategies as embedded within the mental representation of a problem is central to the description of schema, and provides an important component to the rationale for this study.

The Information Processing Approach

Gestalt approaches to problem-solving research were criticized for providing few general principles that supported theory development. Subsequently, behaviorist and associationist approaches were criticized for failing to provide substantive analyses of the components of problem-solving performance (Greeno, 1978, p. 240). Thus, by the 1970s, the information processing approach became the predominant approach to the study of problem-solving in the cognitive sciences (Newell & Simon, 1972).

The general problem-solver (GPS) was introduced by Ernst & Newell in 1969. The GPS proposes, among other things, that a general model of problem-solving may be adequate to account for successful problem-solving across problem type, problem context, and problem-solver's background knowledge. The GPS was intended as a demonstration program for solving a wide variety of problems--typically mathematical and logic problems. Among the operations the GPS performs (Mayer, 1983, p. 183):

- Translating a problem statement into standard components of initial problem state, goal state, and legal operators
- Breaking the problem down into a hierarchy of goals and sub-goals
- Applying strategies drawn from the means-end analysis problem-solving technique
- Advancing from one sub-goal to the next until the problem is solved

A cursory comparison with the anomalous states of knowledge (ASK) system (Belkin et al., 1982) in information retrieval literature reveals similarities in concept, purpose, and process.

The work of Newell & Simon (1972) developed the information processing theory of knowledge construction, and contributed to the burgeoning interest in artificial intelligence at the time. This

approach offered a very precise theory of human thinking and a method for testing it. This approach attempted to capture the processes of human thought in a computer program, and identified a number of concepts that contributed to our contemporary understanding of human problem-solving—in this way, humans could be thought of as information processing systems. Newell & Simon described the problem space as the gap between a current state of understanding and a goal state. This problem space could be mapped out through the identification of objects associated with the defined problem, properties related to these objects, and relationships between the objects. Then, the problem-solving task was to locate a pathway through the problem space using heuristics such as means-end analysis. Simon & Simon (1978) used this approach in a study of physics students. They found that experts used a forward-working strategy, in which they considered the features presented in the initial state in moving toward the goal state, whereas novices used a backwards-working strategy—working from the goal state back to the initial state. The focus in these studies is on the solution search phase of the problem-solving process, and not on the initial stage of problem representation.

Newell & Simon identified concepts that endure in problem-solving research. For one: problems are situated in unique task environments which will determine the possible structure of the problem space, which in turn determines the range of solutions and the appropriate behavior of the problem-solver. For another: the problem statement presented to the problem-solver becomes translated into a mental representation of the problem that determines the structure of the problem space and ensuing search strategies through the problem space to the goal state.

The information processing approach to problem-solving has been characterized as limiting by many cognitive science scholars. Information processing-based research has been founded on the assumption of problems being well-defined; that is., the objects, properties, and relationships of

the problem space are easily identifiable, as are the origins of the problem and the goals of the problem-solving process. However, well-defined problems such as these—logic puzzles, mathematical word problems, chess moves, and the like—are rarely found in natural settings (Jonassen, 2011). Current conceptions of human problem-solving recognize the complex and subjective nature of a problem schema, the impact of domain knowledge, mutable problem types, the opportunity for novel solutions, and the unanticipated effects of social and situational contexts—to date, these dimensions cannot be replicated by a computer program, or by computational approaches to problem-solving. In Gestalt terms, this approach only models reproductive thinking; productive thinking, however, is so crucial to problems found in everyday life.

Toward Contemporary Approaches to Understanding Problem-Solving

Numerous studies mark the progression from approaches to understanding problem-solving based on the information processing approach, which focuses on solution strategies, and toward the contemporary approach based on a focus on problem representation. While rooted in the tradition of information processing, the extensive work of de Groot (1965) in the domain of chess produced results that could be interpreted as being at odds with the conventional wisdom of the day. De Groot produced a staged model that described the thought processes of chess experts upon seeing an authentic setup of playing pieces on a board (that is, orientation, exploration, investigation, and proof); progression through these phases occurred in a matter of seconds after seeing the board. Findings could not easily be explained by the information processing approach—suggesting that there was more to the initial phase of problem representation than what was accorded it at the time. The differences between experts and novices in chess must be attributed to the way the problem is understood (or represented), as well

as the way in which domain knowledge of chess is organized. Subsequent studies by Chase & Simon (1978), Chi et al (1981), and others corroborated the significant role of problem representation, and highlighted the importance of domain knowledge in the problem-solving skill of experts. Jonassen contends (2004, p. 59): “The key to problem solving is how the problem solver represents the problem space, that is, how solvers represent or frame the problem to themselves.” Simon concurs: “...solving a problem simply means representing it so as to make the solution transparent.” (H. A. Simon, 1981, p. 153). Reisberg states: “there are plainly better and worse ways to define a problem—ways that will lead to a solution, and ways that will obstruct it” (Reisberg, 2006, p. 494).

Research on expertise and expert performance suggests an alternative to the information processing approach. Contrary to a general-application approach, expertise in one domain does not guarantee expertise in another domain (Inagaki, 1986). Moreover, experts spend a greater proportion of their problem-solving time on the initial stage of problem representation prior to generating a solution (Chi et al., 1981), experts summon appropriate problem representations that guide further processing more rapidly than novices (Chase & Simon, 1973; Lesgold, 1984), and experts are able to adapt their problem representations more specifically to the features of the target problem situation than novices (Voss, Greene, Post, & Penner, 1983). These studies highlight the relation of problem representation to task success. As noted by Chi (Chi, 2006a): “Subsequent work on expertise attempted to focus on how domain knowledge is represented in a way that leads to better solutions... Thus, the expertise work in the ‘80s reemphasized the understanding phase of representation, but it differed from the earlier work on insight and other knowledge-lean [well-structured] problems in that the focus was on the structure and organization of domain knowledge, and not merely on the structure of the problem” (p. 169).

2.3.2 Expertise and Expert Performance

The study of expertise and expert performance in the cognitive sciences is a burgeoning domain. Theories are developing to explain a myriad of identified phenomena. Relevant to this study is a theoretical framework proposed by Simon & Chase in 1973 (Ericsson, 2006). This framework and its derivations address expertise as qualitatively different representation and organization of knowledge. The theoretical assumption of research on experts and expert performance is that experts' knowledge structures and the ways they represent problems and new challenges are the primary factors in their effectiveness in learning, thinking, and reasoning (Chi, 2006a). The performance of experts is superior to that of novices because they possess superior domain knowledge, not necessarily because they possess any superior capacity for cognition (Ericsson & Lehman, 1996). Moreover, experts just don't have more knowledge in a particular domain—the knowledge that they do have is structured differently than that of novices.

Current research in problem-solving predominantly focuses on domain experts, and is helpful in understanding the progression along the continuum in a variety of domains from novice to expert (Chi, 2006b). Moreover, it attempts to explain how domain knowledge is represented in a way that leads to more effective problem-solving. A number of studies have examined the problem-solving effectiveness of domain experts in chess (Gobet & Charness, 2006), physics (Chi et al., 1989; Chi et al., 1981), medicine (Norman(Norman, Eva, Brooks, & Hamstra, 2006), and firefighting (Klein, 1998), among others. Sabers, Cushing & Berliner (1991) found declarative and procedural knowledge differences between experts and novices in teaching. Characteristics of experts were also examined by Wineburg (1991, 1998) in the domain of history.

Patterns emerge from a review of these studies; these patterns help to illuminate differences between novice and expert problem-solvers, and reveal the following characteristics of experts (Bransford et al., 2000):

- **Patterns of Information.** Experts recognize underlying features and meaningful patterns of information, and recognize deeper structures of problems (Hardiman et al., 1989; J. Larkin, McDermott, Simon, & Simon, 1980). Chi et al (1981) found that expert physics students categorized problems on the basis of physical principles related to the problem's deeper structural features. Also, Chi et al (1989) found that good students recognized the key structural components and their relationships in explanations of worked-on examples, whereas poor students did not. Mestre (1993) demonstrated that novice physics students could improve their problem-solving skill after only five hours of instruction by focusing on the underlying structure and principles of physics problems. Moreover, experts are able to chunk information into meaningful patterns (Catrambone, 1998; Chase & Simon, 1973). Another study used the Structure-Behavior-Function (SBF) approach to uncover the nature of knowledge structure differences between experts and novices (Hmelo-Silver & Pfeffer, 2004).
- **Knowledge Organization.** Experts' content knowledge is organized in ways that reflect a deeper understanding of their content domain; it is organized around core concepts that guide their thinking (Bransford, 2000, p. 36). Snyder (2000) examined the ways in which an understanding of models and theories affected performance by experts in physics. Essentially, expert's knowledge is "cross-referenced"—linked together by associations (Bedard & Chi, 1992)(Bedard &

Chi, 1992). One study explored the deeper causal and ecological relationships within the knowledge of experts in marine life (Shafto & Coley, 2003) (Shafto & Coley, 2003).

- **Conditionalized Knowledge.** Experts' knowledge is conditionalized on a set of contextualized circumstances; that is, experts may engage only a relevant subset of their vast store of domain knowledge for a particular problem (Bransford, 2000, p. 42). The effects of minimal impact on working memory are a boon to experts--Cognitive Load Theory attempts to explain these benefits (Merriënboer & Sweller, 2005).
- **Knowledge Retrieval Fluency.** Experts retrieve knowledge easily; the processes involved in the recall of relevant information nears automatic. Bransford et al (2000) recognize the importance of the initial stage of problem representation: "An important aspect of learning is to become fluent at recognizing problem types in particular domains...so that appropriate solutions can be easily retrieved from memory" (p. 44). However, because experts attempt to understand problems before executing a solution strategy, they may not necessarily be faster than novices at solving problems.
- **Effective Strategies.** Another telling characteristic of experts is that they tend to use a working-forward strategy; that is,, working from the current state to the goal state; novices, on the other hand, will often resort to a working-backward strategy, seeking to adjust the goal state to make it more like the current state. Experts recognize the type of problem they are dealing with and the type of appropriate solution within their domain (Bedard & Chi, 1992; Gick, 1986; Larkin, et al.,

1980). Thus, experts know they will be successful from the start--supporting the proposition that problem representation is crucial to successful problem-solving. Even experts, however, will use the novice strategy of working-backward when faced with a problem with which they are unfamiliar, or in a new domain (Gick, 1986), so the impact of background knowledge in the content and process skills related to a particular domain must be considered.

- **Teaching and Transfer.** Interestingly, experts are not consistent in their ability to convey their knowledge to others, and to transfer their skills to novel situations and domains—the “transfer problem” (Bernardo, 2001; Didierjean, 2003; Hatano & Oura, 2003; Inagaki, 1986; Mayer, 1998; Mayer & Wittrock, 1996; Novick & Hmelo, 1994).

These and related studies focused attention on a conceptualization of problem representation which included an embedded solution strategy. Since these characteristics are brought to bear upon problem-solving situations, and distinguish experts from novices within a given domain, this research serves as a rich resource in understanding parallel processes within information problem-solving. These studies suggest that the problem representations of experts are more sophisticated than those of novices as a result of more complex and robust schemas for problem situations in a particular domain. Thus, expert problem representation is likely to lead to successful solution generation, just as skilled Task Definition is likely to lead to successful solution strategies in the information problem-solving process.

2.3.3 Schema and Categorization in Problem Representation

The Gestaltists viewed thinking as an examination of the way in which problem elements relate to one another and are organized into a meaningful structure—it was assumed that these

relationships are inherent to the problem itself and independent of the problem-solver. A later approach, cognitivism, which grew out of a critical judgment of the predominant approach of behaviorism, focused on internal cognitive processes, and recognized the existence of mental states. In this view, thinking is an assimilation of problem elements, their properties, and their relationships, into the problem-solver's own knowledge structure where schema is accessed and meaning is made. Therefore, the relationships among elements within a problem only have meaning if they can be assimilated.

The concept of schema has been described by Rumelhart & Ortony (1977), among others, and serves to explain problem representation. A problem schema includes both structural and situational characteristics of a problem (Jonassen, 2011, p. 248); that is, characteristics of the problem type and context. It is access to a problem schema that establishes an initial understanding of an encountered problem, and suggests strategies for solving it. Research indicates that a highly-developed, or robust, problem schema is positively correlated with a successful solution (Dufresne, Gerace, Hardiman, & Mestre, 1992; Gick, 1986; Littlefield & Rieser, 1993; Sweller, 1988; Taconis, Ferguson-Hessler, & Broekkamp, 2001). Domain experts recognize the underlying structural and situational characteristics of problems, likely because they have developed robust problem schemas. In studies of children's learning of mathematics, particular schemas were identified: "cause/cause," "combine," and "compare"; moreover, there is evidence that these particular schemas for math problems are developed in that order (Greeno, 1980; Riley & Greeno, 1988). Alberdi et al (2001) studied junior and senior physicians, and corroborate findings in other domain studies that differences between experts and novices may be attributed to domain knowledge and knowledge representation, or schema.

The concept of schema facilitates an understanding of the crucial role of problem categorization—when a problem is encountered and categorized, schema is activated and an embedded solution strategy is immediately implemented. When a problem-solver identifies a problem situation, one of three courses will be taken during the problem representation stage: a) analogical thinking will match the perceived elements of the problem to an established, well-defined schema for that category of problems, b) the problem will be matched to a poorly-defined schema, or c) there will be no schema at all for the category of problem perceived by the problem-solver, and the solver will experience uncertainty with how to proceed. Since schema will guide the subsequent stage of employing a solution strategy, it would be reasonable to expect that experts have better-defined schemas—and likely more categories of schemas—in their particular domain than do novices, and are thus more effective problem-solvers. Chi et al (1981) relate this concept to categorization: “More particularly, some evidence already exists in the literature to suggest that solvers represent problems by category and that these categories may direct problem solving.” (p. 123).

In a review of research on problem-solving strategies, Gick (1986) synthesized the principles of problem-solving models into a common set of problem-solving strategies. She found the need to distinguish between schema-driven and search-based strategies, and applied this distinction to an examination of the differences between novices and experts. She found that strategies that facilitated schema learning were effective, and that certain search-based strategies actually hindered schema development; for example, means-end analysis. She also considers the implications of research for practice, and frames an approach that holds to this day: “...I continue to distinguish between schema-driven and search-based strategies. The first issue considered is whether the learning of schema-driven strategies (that is, those invoked by problem

schemata) can be facilitated. Particular attention is given to improving the learning of schemata and the training of domain-specific strategies. Consideration of general strategies follows, with three questions addressed: Can the use of general strategies be improved within a problem domain? What governs the use of general problem-solving strategies? Can the improvement in general strategies be transferred to other content domains?" (1986, p. 110).

Gick then reviewed a number of problem-solving approaches, and offers a composite model (p.101). Note that when schema is activated, a solution strategy is embedded and immediately implemented.

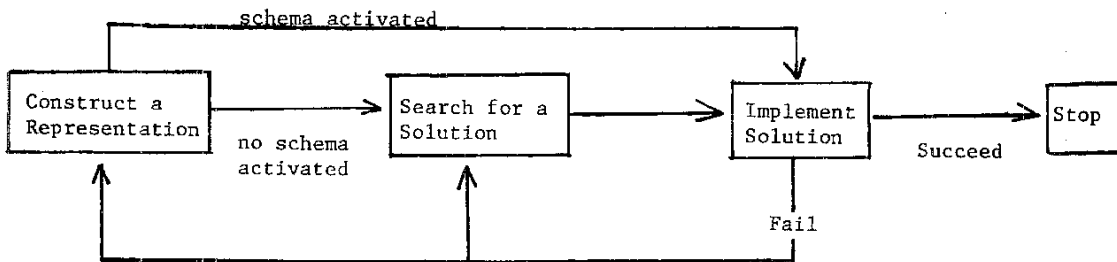


Figure 1 Schematic diagram of the problem-solving process.

From Gick (1986), p.101.

This model is iterative in that the problem-solver may repeat stages of the process; for example, a failed solution attempt will likely cause the problem-solver to return to the construction stage and modify the schema in use, or abandon it altogether. Note that approaches to problem-solving from the cognitive sciences are not interested in the acquisition of new information in order to solve problems. This is evident in the types of tasks traditionally used in problem-solving research: logic problems/puzzles, mathematics and physics problems, and chess. Only recently

have the dimensions of ill-structured problems; that is, the type found in everyday life and workplace contexts, been accounted for in problem-solving research.

2.3.4 Analogical Reasoning and Structure-Mapping Theory

As applied to the study of problem-solving, analogical reasoning relates what is known about a current problem situation to another in memory established through prior experience. The assumption is that when there are meaningful parallels between two situations, there will likely be more information that can be inferred, according to structure-mapping theory (Gentner, 1983). In the initial phase of problem-solving, a person will perceive the apparent components of the problem; in cognitive terms, the elements, their properties, relationships between elements, and constraints. In situational terms, the problem type, the problem-solver's induced schema, its situatedness within a social, physical, and temporal context. People will experience this process in varying degrees according to declarative and procedural knowledge of these factors; typically, experts will recall representations of the problematic situation that are more robust and reflect the underlying structure.

Holyoak (1984) has described how analogical thinking is involved in all problem-solving in his development of a theory of analogical thinking. In essence: "The schema is the abstract category of which the specific analogs are the instances" (Holyoak, 1984, p. 208). Holyoak goes further to define the process of schema induction: "In essence, the process of abstracting a schema by eliminative induction involves deleting differences between the analogs while preserving their commonalities" (p. 208). As an example, the two stories used in the study may be reduced to "rays destroy tumor" (target analog, since it is the problem to be solved) and "army captures fortress" (base analog, since it must be recalled from memory); the schema would be "overcome (force, target)." Thus, the surface features of the target analog must be ignored in order for the

mapping between “rays destroy tumor,” which resides within the schema “overcome” and “army captures fortress” to occur. Finally: “An explicit problem schema will make salient those causal aspects of a situation that should trigger a particular plan of action” (p. 213). Thus, a robust and explicit schema will identify a course of action, or the generation of a suitable solution.

Structure-mapping theory (Gentner, 1983; Gentner, Loewenstein, & Thompson, 2003) describes the cognitive process of structural alignment, in which setting up of correspondences between structured representational elements in two different domains or situations allow for the transfer of information guided by a common relational structure (Jonassen 2011, p. 260), allowing for analogical reasoning (Bassok, 2003). Structure-mapping theory is useful in understanding several findings from the cognitive sciences related to analogical reasoning. Jonassen states that the cognitive processes necessary for each and every kind of problem-solving situation are analogical reasoning and causal reasoning (2011, p. 362). It is unknown whether these skills are sufficient for learning to solve problems (others may be needed in addition), but they are necessary in every situation. While analogical reasoning is necessary for the induction of robust problem schemas, causal reasoning is necessary to recognize the causal relationships between problem elements and stimulate solution generation through a process of inference and prediction. Through analogical reasoning, unknown solutions may be derived from those that are already known (Reisberg, 2006, p. 483). Concepts that may at first seem confusing may be made clear by means of analogical reasoning; for example, comparing electricity to water flow, molecules to the solar system, the functioning of the heart to a pump, and the like.

Holyoak (1984) describes the use of analogies in goal-directed tasks in this way: “Analogical thinking is a pervasive component of human intelligence...Analogical thought is used not only to derive solutions to problems but to make predictions, strengthen arguments, and generate literary

metaphors” (p. 201). According to Holyoak, analogical problem-solving involves four processes which are not necessarily linear:

- Representation, in which both a perceived schema of the target problem is constructed and a potential analogical schema is already constructed in memory;
- Notice, in which some aspect of the target schema serves as a retrieval cue to the base schema in memory;
- Mapping, in which an initial and partial set of correspondences links elements, properties, and relationships between the two schemas; and
- Extension, in which the mapping allows for the construction of new knowledge about the target problem.

Analogical thinking allows for the transmission of knowledge from one situation to another, from a familiar situation to a novel one, even in circumstances where the surface features of each are quite dissimilar (Holyoak, 1984, p. 201). It is possible to trace the features of the mapping process by identifying a set of elements in a particular analog (“vertical mapping”), and the correspondences between analogs (“horizontal mapping”); mapped elements, defined as the objects, their properties, and their relationships in a problem, are typically similar but not identical, so they must be broken down into more basic parts (Winston, 1980). Bassok (1996) describes these elements as such: “retrieval and mapping are mediated by matches and mismatches between the objects (that is, aspects of content) and the relations (that is, aspects of structure) comprised in the representations of the base and target problems” (p. 54).

A description of Gick & Holyoak’s 1980 study serves as an appropriate example of analogical thinking processes. In this study, Duncker’s tumor problem (Duncker, 1935/1945) served as the

target problem; a story similar in structure but dissimilar in domain served as an analogy in a series of experiments:

A small country was ruled from a strong fortress by a dictator. The fortress was situated in the middle of the country, surrounded by farms and villages. Many roads led to the fortress through the countryside. A rebel general vowed to capture the fortress. The general knew that an attack by his entire army would capture the fortress. He gathered his army at the head of one of the roads. The mines were set so that small bodies of men could pass over them safely, since the dictator needed to move his troops and workers to and from the fortress. However, any large force would detonate the mines. Not only would this blow up the road, but it would also destroy many neighboring villages. It therefore seemed impossible to capture the fortress (p. 351).

Gick & Holyoak (1980) found that the use of an analogous problem, even from a different domain, can be used to develop an appropriate solution to a novel problem: “Our results substantiate anecdotal descriptions of the role that analogical thinking may play in creative problem solving, and at the same time provide some information about the mental processes involved in analogical problem solving” (p. 346). However, a number of limitations were revealed. For one, that successful analogical transference was significantly reduced when the similarities were not given as a hint that the strategy used on a specific earlier problem may also be useful in solving target problem. Another is that successful transference was also reduced when the analogous problem does not have an exact structural correspondence to the target problem. It seems that the dissimilarity in domains may be a gap too wide to cross unless analogies are overtly similar, and situated near enough to be recalled. Several researchers (Hayes

& Simon, 1977; Reed, 1977; Reed, Ernst, & Banerji, 1974) found similar results in using the “jealous husbands” problem as an analog for the “hobbits and orcs” problem.

In other words, while analogies significantly increase success in problem-solving, people have a difficult time using analogies to solve problems unless similarities are clearly indicated. One reason is that surface features of the problem do not facilitate the effective mapping between target and analog; in the example above, participants who may have been thinking of other problems related to tumors would not have recognized the usefulness of the fortress analogy, which was only similar in the deeper structure of overcoming through accumulated force.

Similarly, participants searching prior knowledge for examples of hobbits were not able to map the underlying structures of hobbit and orc to wife and husband in the jealous husbands example (Gentner, 1983; K. J. Holyoak & Koh, 1987). In Bassok’s terms (1996), differences in object attributes(content) of a problem situation will result in a mismatch in relational attributes (structure), at least when object attributes outweigh relational ones (p. 54).

Strategies Promoting Analogical Reasoning

The development of skills that induce schema and promote analogical reasoning is beyond the scope of this study. However, a review of the related literature may contribute to an understanding of categorization of information problems, and add to the study’s anticipated contributions. According to Jonassen: “Problem solving is a schema-based activity. That is, in order to solve problems, learners must construct schemas for problems...Constructing models of problems...greatly facilitates schema development. Having constructed a robust schema for different kinds of problems, learners are better able to transfer their problem-solving skills”

(2011, p. xxi). Mayer et al (1984) found that the ability to classify problem types is closely related to problem-solving and the transfer of skills.

In addition to straightforward strategies for promoting analogical reasoning—highlighting deeper structures of problem situations and pointing out parallels in object and relational attributes between base and novel situations—other strategies have been determined. In a follow-up study, Gick & Holyoak (1983) found that two or more direct analogies, with essentially similar deeper structures, may be significantly more effective than one. One analogous story may not be enough to call attention to the underlying structure, and a second may do just that; an analogous story that is only partially similar, or only superficially similar, will not produce this effect (Gick & Holyoak, 1980). Moreover, Needham & Begg (1991) found that problem-oriented training is more effective than memory-oriented training--when subjects were told to memorize as many practice problems as they could, their skills did not transfer as well as those told to understand the underlying structure of the practice problems so that they could explain them to someone else. Cummins (1992) had one participant group compare example algebra problems and another simply read them; she found that this type of analogical comparison was an important component in the induction of problem categories.

In a review of literature on the transfer of problem-solving skills, Mayer & Wittrock (1996) identify a number of instructional strategies for the promotion of knowledge transfer from familiar to novel problem-solving situations; chief among these are domain-specific thinking skills and analogical reasoning. The literature also addresses strategies for facilitating skill in problem-solving by addressing problem representation skill. Recognizing that different problems or contexts require different problem representations, Wopereis suggests embedding targeted information problem-solving instruction within the content areas (Wopereis 2008). Gick suggests

that schema-driven strategies may be facilitated (Gick 1986, p.110). These efforts are supported by Lehman et al (1988) who found that domain specificity in problem-solving is crucial to success: students in probabilistic sciences perform better on statistical/methodological/conditional reasoning problems than do students in law and chemistry, who do not learn such forms of reasoning (Lehman et al, 1988). Jonassen (2004) draws attention to the link between research and practice: “Internally representing problems is as important to novice learners as it is to experts. If we want students to be better problem solvers (regardless of problem type), we must teach them to construct problem representations that integrate with domain knowledge” (p.60). Mayer et al (1984, p. 270) echo this need after reviewing numerous studies on mathematical ability, concluding that “students need practice in representing problems and in recognizing those problems that go together and those that do not.”

Story analogies are used in much of analogical reasoning research. Klein suggests a reason for this: an intriguing branch to the study of problem-solving is storytelling (Klein, 1998; Wilensky, 1983). According to Klein, the dimensions of all that can be perceived by humans in the world would be impossible to make sense of were it not for our propensity to tell a good story. A good story serves as a framework for linking perceptions, ideas, concepts and relationships into a coherent pattern. The elements of a good story include agents who are confronted with a problem, their intentions, objects and actions; the effects of their actions; the context of the situation, and unexpected happenings along the way that make the story unique. Moreover, the story must be unique, plausible, and manifest consistency and economy. Klein uses this metaphor in a description of mental simulation, but it also serves effectively to describe problem representation. Jonassen corroborates: “Experiences are phenomenological and are normally conveyed through stories” (2011, p. 21). The use of case libraries is recommended in order to

learn how experienced problem-solvers handled similar problems, particularly those that are ill-structured (Hernandez-Serrano & Jonassen, 2003; Jonassen & Hernandez-Serrano, 2002). Other related evidence indicates that worked examples are effective in developing schema for well-structured problems (Merriënboer & Sweller, 2005).

Studies in analogical problem-solving reveal several insights into the nature of problem representation. There appear to be two processes at work: first, the development of an analogous situation that can be stored in memory; as Klein suggests, this will be more retrievable if it is in the form of a story, either drawn from the person's own experience, or presented through instruction. Next, there is the recall of the analogous situation as appropriate to the target problematic situation. Either the problem-solver will fail to recall the appropriate analogous situation; that is, schema, or will recall a schema that is not appropriate to the target problematic situation; that is, Duncker's functional fixedness (1935/1945).

Of course, extensive knowledge and experience in problem-solving within a particular domain is the most effective strategy for promoting analogical reasoning. However, there are strategies that may be implemented to promote problem-solving skill in non-experts as well: "To this end, we need to encourage students to approach the training problems in an appropriate way, to make certain the training problems will be retrievable from memory later on, and also to provide a basis for seeing the mapping between the training and the test problems" (Reisberg, *Cognition*, p. 489).

2.4 Operationalizing Concepts

An investigation into categorization of information problems during Task Definition will require the operationalization of concepts identified in the foregoing review of the literature. Among

them: “information problem” and “domain knowledge.” The rationale for each of these operationalizations is described below.

2.4.1 Defining “Information Problem”

Mayer (1996) offers a definition of problem-solving: “Problem solving is cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver” (p. 47). Problems may be described as well-defined, where the goal state, the operators, and the obstacles are known to the problem-solver, and ill-defined, where one or more of these components are unknown or unknowable. The Oxford English Dictionary provides a first step in the process of operationalizing the concept of information problem. The first definition supplied describes well-structured problems: “A puzzle; a riddle; an enigmatic statement”; whereas the third definition describes ill-structured ones: “A difficult or demanding question; (now, more usually) a matter or situation regarded as unwelcome, harmful, or wrong and needing to be overcome; a difficulty” (“problem, n.,” 2011).

The field of library and information science is concerned with information problem-solving. Information problem-solving is an appropriate term to use for any situation in which information is needed to answer a question, complete a task or assignment, or solve a problem. The recognition of a need for information outside of the problem-solver’s knowledge base logically pushes any definition of an information problem along the continuum from well-structured to ill-structured. Wopereis, Brand-Gruwel & Vermetten (2008), in their review of information problem-solving literature, identify problem type and context as factors in an investigation of information problem-solving:

The complexity of IPS can be illustrated by zooming in on the concept of information problem. Just as 'normal' problems, information problems can be described in view of four elements: (a) an initial state, (b) a goal state, (c) a solution that enables the transition from the given state to the goal state, and (d) the problem solving process itself (cf. Newell & Simon, 1972). In case of an information problem, the initial state of the problem is an information need, the goal state is the situation when this need is fulfilled (information is found, processed, and presented), the solution is a set or sequence of IPS strategies, and the (information) problem solving process itself is the application of this set or sequence (p. 740).

Research in the library and information science literature indicates that characteristics of the task itself are related to information behaviors (Bilal, 2000, 2001, 2002; Tu 2008). Large, Beheshti & Breuleaux (1998) found that children's information seeking is more significantly influenced by type of search task (simple v. complex) than by source type (print v. CD). Bilal (2001) concludes, "mediators should ensure that children learn adequate research skills and know how to discriminate between different types of research tasks (that is, fact-based and research), regardless of the IR system they use" (p. 134). Bilal & Kirby (2002) found: "children had more difficulty with the research-oriented task than with the fact-based task" (p. 112); children had more difficulty with the imposed research-based task than with the self-generated research task. Similarly, studies by Head & Eisenberg (2009a, 2009b, 2010a, 2010b) found there are differences in the way students approach course-related assignments than they do every-life questions. Gross (1995) identified differences between the imposed query and the self-generated query.

Bystrom and colleagues (Bystrom, 2002; Bystrom & Hansen, 2005; Bystrom & Jarvelin, 1995) embarked upon a comprehensive and detailed analysis of the impact of task complexity on information behavior. The treatment of task in these studies is essentially the same as the concept of problem within problem-solving research, and is useful in analyzing the concept of information problem. Findings from their first study on civil servants include:

- Information related to the task may be defined by three categories: problem information, domain information, and problem-solving information.
- An information source contains information relevant to the task; a channel guides the individual to the information source—information may be accessed through various channels and sources.
- Information-related tasks may be seen as either perceived (subjective) or absolute (objective) tasks.
- There are five problem types, from automatic tasks to genuine tasks.
- As task complexity increases, information needs become more complicated, the needs for domain and problem-solving information increases, there will be a predictable impact on sources and channels needed, and the success of information seeking decreases.

Bystrom (2002) found that different levels of perceived task complexity will affect access of information type, source, and channel: “The specific research problem studied was what types of information (that is, PI, DI, PSI) are sought for through which types of channels (i.e., external, internal) from what kinds of sources (e.g., experts, literature, official documents) in which kinds of tasks (i.e., automatic information processing tasks, genuine decision tasks)” (p. 196). Vakkari (1999) reviews the concept of task, and concludes: “Task complexity and the related structure of

the problem are crucial factors determining task performance. They are connected to the types of information people are looking for and using, to patterning of search strategies, and to choice of relevance criteria in tasks” (p. 834). Bystrom & Hansen (2005) recognize the limitations of their approach: “We acknowledge that the concept of task does not cover all information activities that are of interest for the field of information studies. Everyday life situations in particular may not be as expressly goal-oriented in their resolution seeking as work tasks are” (p. 1058).

Bystrom & Hansen (2005) review the library and information science literature related to tasks. They recognize two approaches: a concept of task itself, and the context of task. They draw from the literature in developing a concept of task, and identify task descriptions that direct task processes. They define task levels and the corresponding information actions, and corroborate models of information problem-solving: task construction, task performance, and task completion. Their description of the initial phase of task construction is by now familiar: "Task construction plays a major role in the other parts of the task but is impossible to observe directly and difficult even to communicate fully" (p. 1054). They note that the task performer will have formulated possible information seeking and search strategies in this phase.

Bystrom & Jarvelin (1995) examine the role of the task as perceived by the problem-solver and conclude that the task will impose information requirements and guide subsequent information seeking activities: “the perceived task always forms the basis for interpreting information needs and the choice of promising actions for satisfying them” (p. 193). These researchers adopt useful approaches to their investigation of tasks; the first approach relates to the type of problem encountered by the problem-solver and the other relates to the type of information perceived as needed by the problem-solver. This approach corresponds to the sub-stages of Task Definition as described by Eisenberg & Berkowitz (1989): define the task, and identify the information needed

to complete the task. The types of problems may be broken down into five categories according to the a priori knowledge the problem-solver brings to bear upon the determination of the information needed (inputs), the processes necessary for problem solution, and outcomes. Thus, at the first level of automatic information processing tasks, all three components are determinable by the problem-solver; an example of this is a simple calculation. The fifth level, or genuine decision tasks, are characterized by a lack of determinability in all three areas, such as foreign policy issues. This approach is similar to the problem typology developed by Jonassen (2000), but adds the essential component of information perceived as necessary to solve the problem which is of primary interest to a library and information science investigation.

Bystrom & Jarvelin also describe a useful approach for classifying the type of information needed in tasks. Problem information “describes the structure, properties, and requirements of the problem at hand” (p. 195), domain information consists of “facts, concepts, laws, and theories in the domain of the problem” (p. 195), and problem-solving information “covers the methods of problem treatment” (p. 196).

This review of the library and information science literature related to task corroborates a number of findings from the cognitive science literature. For one, that "task construction is perceived as a rather difficult part of the task performance process by its performers" (p. 1054), that performers may spend less time in this phase in situations where they are familiar with the task, that tasks may be perceived and constructed as simple or complex, that tasks will have a more or less defined structure, and that the task performer's prior knowledge and experience plays an important role in the process.

Although problems will differ according to structural and situational characteristics, patterns emerge that enable the identification of problem types. A number of problem types have been identified (Greeno, 1978), and refined (Jonassen, 2000, 2011)—each will affect the way a problem is mentally represented. Problem isomorphs (H. A. Simon & Hayes, 1976) address issues of problem structure; other dimensions include complexity, dynamicity, and domain specificity. Mayer et al reviewed a number of studies related to mathematical ability and conclude: “People who are unable to generate the correct answer may lack the knowledge of problem types” (Mayer et al., 1984). Another consideration of problem type is whether it is an imposed or self-generated task. Gross (1995; 2001) examined these dimensions of problem type and found that there are distinct differences in the behaviors of users of library services and information systems according to these distinctions. Jonassen developed a typology of problems, identifying the kinds of problems typically encountered, and characteristics of each of these kinds of problems, from logic problems to troubleshooting to dilemmas (2000).

Problem-solving research has been based upon the well-structured problem. These types of problems will have four elements (Jonassen, 2011):

1. Goal: state of knowledge toward which the problem solving is directed
2. Givens: objects, conditions, and constraints that are provided with the problem, explicitly or implicitly
3. Means of transformation: ways to change the initial states
4. Obstacles: steps unknown; goal can't be directly achieved

Problem structuredness is the the degree to which one or more of these elements is not known to the problem-solver (Jonassen, 2011). As is typical of problem-solving research in the

information processing tradition, the types of problems examined are well-defined; these lend themselves to the sort of research which can be executed in a laboratory and variables can be controlled with precision. While well-structured problems achieve the goals of internal validity in empirical research, their employment reduces external validity—findings may not be generalizable to the population outside of the laboratory. Since the publication of Newell & Simon’s seminal work (1972), numerous studies have found that the cognitive processes brought to bear upon well-defined, or well-structured, problems are different from those engaged in confronting ill-structured ones (Shin, Jonassen, & McGee, 2003; Schraw, Dunkle, & Bendixen, 1995). Chi (2008) identifies the current lack of and need for research on ill-structured problem-solving behavior in real-world domains (p. 170). Moreover, Jonassen noted in 2004 that no research existed on how complex, ambiguous, and ill-structured problems affect problem representation (Jonassen, 2004).

Some researchers have examined different types of information inherent in information problems: “Among the three information types (problem information, domain information, problem-solving information) that are usually needed to carry out search tasks, problem-solving information relates to experience-based aspects like prior knowledge of how a similar problem was solved” (Singer, Prullmann-Vengerfeldt, Norbistrath, & Lewandowski, 2012).

As described by Bystrom and colleagues, the interplay of problem characteristics and problem-solver’s background knowledge will determine an information problem’s perceived structuredness, complexity, and dynamicity. The ambiguity of defining a conception of information problem may be avoided by determination of focus. In this study, tasks will be developed based upon the dimensions suggested by the research of Bystrom and colleagues, and

by the problem typology described by Jonassen (2011). However, the focus during analysis of the data will be on the information perceived by the participant as needed to solve the problem.

Experts in information problem-solving will be operationalized as experienced reference librarians. As rationalized in Chapter 2, experienced reference librarians have been trained in the content knowledge and pedagogical content knowledge of the domain of librarianship (L. S. Shulman, 2000). Content knowledge will include the nature of information sources (contain information) and channels (guides the user to relevant sources), as well as the organization of information sources, channels, and the information within sources (Bystrom & Jarvelin, 1995). Through practice, reference librarians also develop an understanding of the classifications of information types (problem information, domain information, and problem-solving information) and problem types. Problems presented to reference librarians may be classified according to perceived complexity (Bystrom & Jarvelin, 1995) and typology (Jonassen, 2000). Through practice, these librarians also develop pedagogical content knowledge; that is, the ability to effectively convey to the user an understanding of content knowledge through a variety of methods. Experienced reference librarians are defined by the researcher as those having 10 or more years of experience within a public or school library setting; 10 or more years has been proposed as the length of time necessary to develop expertise within a particular domain (Hayes, 1981).

2.4.2 Operationalizing the Concept of “Domain knowledge”

Many scholars have described knowledge as having two components: declarative (know-what) knowledge, and procedural (know-how) knowledge (Anderson, 2010). In fact, neuroscientific studies find that these two types of knowledge are located in different regions of the brain (Charness, Milberg, & Alexander, 1988), and appear to support such a conception of knowledge.

Ju (2007) operationalized this concept of knowledge in a study measuring the effects of the two components. Geography majors were recruited to represent declarative knowledge experts and Computer Science majors to represent procedural knowledge experts in a study of how the two groups compared using complex Geography Information System (GIS) software. The study found that both types of knowledge were important in interaction with this system, and that there are differences between these two types related to task. Sabers et al (Sabers et al., 1991) found declarative and procedural knowledge differences between experts and novices in teaching. A review of literature on expert and novice differences in teaching (Hogan, Rabinowitz, & Craven, 2003) found that expert teachers not only have deeper knowledge of domain content but elaborate schema, whereas novice teachers did not. Expert teachers focus on structural features of problem situations in categorizing problems, whereas novice teachers did not (Hogan & Rabinowitz, 2009). The tasks used in the study by Hogan & Rabinowitz (2009) were classroom-based situations which varied on the basis of surface features (grade level and subject matter) and deep, or structural, features (assessment, instruction, and classroom equity).

There is a familiar and lingering debate in the cognitive sciences over whether problem-solving skills may be described by a general model that transfers successfully from one situation to the next, within and between domains. The heuristics recommended by Polya--analogies, induction, pattern-matching, and the like--are typical of the search-based strategies promoted by the information processing approach. Some identify these as “weak methods,” inadequate in accounting for the superior problem-solving performance of experts (Holyoak, 1984). However, a case may be made that domain-specific expertise is built upon the application of domain-general strategies in specialized ways. Bransford & Stein (1984), in their introduction of the

IDEAL Problem-Solver, acknowledge the limitations of domain-general strategies, and suggest that these may be overcome by applying the model differently to different problems.

Efforts to integrate models of problem-solving into a universal theory of problem-solving in the cognitive sciences (Greeno, 1978; Greeno, 1980; Smith, 1991) are relevant to the topic of two types of knowledge. Smith (1991) initiated an attempt to corral reviews of research in a number of domains in an effort to identify a unified theory of problem-solving. Smith makes clear, however, that his efforts to move consensus toward a unified theory have not produced an actual unified theory. He identifies the two major challenges toward this goal as the lack of a clear definition of “problem,” and the failure of consistent transfer of problem-solving skills from one domain to another. His charge for contributing authors was to address the transfer problem by identifying commonalities among findings from a diverse array of domains. These efforts were abandoned, however, and the lack of a unified theory remains. It is interesting to note, however, that the contributing author for the chapter on “troubleshooting,” Ray Perez, came to a slightly different conclusion than others from domains more familiar to problem-solving research such as physics, medicine, and mathematics: “The evidence from the research on electronic troubleshooting suggest that to perform troubleshooting tasks technicians need to have both “how-it-works” knowledge and “what-it-is” (declarative) knowledge of the systems they are asked to maintain” (Smith, 1991, p. 145). This notion of two kinds of knowledge is applicable to a conceptualization of information literacy which accounts for both declarative and procedural knowledge, and is consistent with the most current research on expert performance.

Information Literacy as Expertise

Studies of expertise and expert performance reveal characteristics of the expert that have much in common with stated characteristics of information literacy. A conceptualization of information literacy may be further developed as the study of expert performance in information behavior. Information literacy studies indicate a combination of both domain-specific and domain-general strategies; a consideration of procedural knowledge as the set of “weak strategies” when combined with the “strong strategies” of declarative knowledge is characteristic of adaptive expertise (Hatano & Inagaki, 1986; Wineburg, 1998), and may suggest a conceptualization of information literacy as envisioned by Lloyd (2005, 2006, 2007, 2009; Lloyd & Williamson, 2008). Pettigrew et al (2001) may suggest a definition of information literacy that explains expert performance both within a given domain and across domains: "...information science itself is an orthogonal field that examines info phenomena across different settings using interdisciplinary perspectives." (p. 67)

The notion of two types of knowledge in consideration of expert-novice differences is not new to the field of library and information science. Lazonder et al (2000) used an expert-novice approach to study differences in information seeking behavior. They chose domain expertise as a controlling variable to compare the performance of their subjects with regard to experience in online search. This approach could be characterized as controlling for declarative knowledge to compare differences in procedural knowledge between experts and novices. They found that subjects with expert procedural knowledge did indeed demonstrate superior performance. Moreover, they found that regardless of expertise in procedural knowledge, subjects performed the same on locating information within web pages (essentially, a reading task); this is supported by hypertext research. It is interesting to note that the researchers make the following reference:

“true experts such as librarians and information scientists” (p. 580). This indicates a conception of librarians as experts, at least in the procedural knowledge across domains.

Information literacy may be characterized as expertise in procedural (process skills) knowledge couple with domain (content) knowledge. This working concept of information literacy may approach that described by Lloyd. In her series of studies on work place information literacy (2007, 2009), Lloyd conceptualizes information literacy as navigation through a landscape. In her work with firefighters, she discovered a way of knowing about the explicit and tacit knowledge inherent in each work environment; in this way information literacy is viewed as savvy human information behavior that is in tune with the task, situation, and context in which information is embedded. While Limberg (2008) suggests that Llyod’s approach is a rejection of “generic skills applicable across disciplines and contexts,” it may in fact suggest an approach to information literacy that is an integration of domain-specific and domain-general problem-solving strategies. Tuominen et al (Tuominen, et al., 2005) appear to concur: “The article suggests that studying and understanding the interplay between information technologies, workplace learning, and domain specific knowledge formation processes is necessary for the advancement of information literacy initiatives” (p. 329).

Fields (2006) initiates an intriguing discussion about the factors coming into play in determining expertise. Her work suggests a framework for describing the factors of expertise level and type of domain knowledge (declarative and procedural). This framework accommodates combinations of these factors. For example, while a lawyer’s domain knowledge may make him/her an expert, he/she may not have the IL skills to be considered a true expert—here a law librarian fits the bill. Likewise, a reference librarian may be expert in the procedural knowledge of information access, evaluation, and use, he/she lacks the context of domain knowledge. In the academic setting from

which Fields' work is drawn, students represent true novices—neither expert in the knowledge of any particular domain, nor in IL. She makes a strong case for partnerships of experts and novices in the development of IL under conditions determined by ill-structured problems: “Little or no attention, however, has been devoted to the information novice – the student – and the information expert—the reference librarian—working together to solve ill-structured problems involving finding, evaluating, and using information...Just as problem structures range along a continuum [from well-structured to ill-structured], so do problem solvers range along a continuum from novice to expert” (p. 410). This may be an exciting and appropriate approach to the study of information literacy.

Expertise research reveals a number of corresponding concepts, but to date no studies have established a relationship between these literatures. The establishment of a bridge from the literature of expertise and expert performance to information literacy affords theory and methodological tools that promise to accelerate the maturation of information literacy as a domain of research. This study takes a multidisciplinary approach in incorporating theory and methods, and aims to establish such a bridge.

2.5 Summary: Conceptual and Theoretical Framework

As stated by Sosniak in her review of literature related to retrospective interviews in expertise and expert performance research: “Theory-driven work is important because only in this way can we clearly focus our attention for data collection and analysis, and make reasonable efforts to look for both confirming and disconfirming evidence” (2006, p. 295). The numerous cognitive processes engaged during Task Definition have not yet been described by a particular theory in any field. Theories proposed by library and information science scholars, in addition to

applicable theories from the cognitive sciences, serve as the framework for this study. This section provides an overview of the conceptual and theoretical framework for this research.

Cognitive constructivism, as a theory interpreted by Kuhlthau in the information search process (2004) and described by Talja, Touminen & Savolainen (2005), serves well as a meta-theoretical approach to the investigation of the research questions posed by this study. The constructivist approach provides a rational explanation for the progression toward information literacy through a continuous series of experiences through the information problem-solving process described by Eisenberg & Berkowitz (1990). The phases of knowledge construction are congruent with the levels of need described by Taylor (1968), the progression from gap in understanding to knowledge through sense-making (Dervin, 1998), and from an anomalous state of knowledge to a new conceptual state of knowledge (Belkin & Oddy, 1982). Talja, Touminen & Savolainen (2005) describe Kuhlthau's application of cognitive constructivism in this way: "With its emphasis on situational and subjective relevance (user-subjective approach), cognitive constructivism is a theoretical approach that is eminently suited for studying task-based information seeking. It is especially applicable in integrated studies on information seeking and retrieval" (p. 87). Eisenberg & Berkowitz' Big6 information literacy approach has been effectively employed in research and in practice. It describes the initial stage of Task Definition within the context of the entire information problem-solving process, and serves as a guide for the development of the conceptual framework for this study.

Structure-mapping theory (Gentner, 1983; Gentner et al., 2003) describes the cognitive process of structural alignment, in which setting up of correspondences between structured representational elements in two different domains or situations allow for the transfer of information guided by a common relational structure (Jonassen 2011, p. 260), allowing for

analogical reasoning (Bassok, 2003). Together these describe the categorization of information problems, and guide the manipulation of variables, in this case domain expertise and domain knowledge. This will enable the researcher to investigate the Task Definition stage of the information problem-solving process in order to determine its importance in successful information problem-solving. To date, no research has employed these theories in an investigation of problem categorization with a focus on the information features of problems; that is, task definition. Thus, while problem-solving research reveals a number of corresponding concepts, to date no studies have established a relationship between the concepts of problem representation and task definition—this study addresses that need.

The proposition that information literacy skills are domain-general may be supported by CLT. From educational psychology literature comes Cognitive Load Theory (CLT), which incorporates a number of concepts addressed in this review. CLT advocates the use of principles related to cognition and information structures to inform instructional design; a focus of the theory is on the ability of working memory to process information with ease (Merriënboer & Sweller, 2005). According to CLT, reducing the load on working memory during learning activities and problems-solving enables deeper and more meaningful integration of new information. CLT recognizes the role of schema in the processing new information, as it combines many simple concepts into more complex ones which can then be stored in long-term memory. Thus, the burden on working memory is reduced because even the most robust and complex schema can serve as one element; when information is readily retrieved from long-term memory, there is no known limitations to working memory (Ericsson & Kintsch, 1995). CLT's mandate: "From an instructional design perspective, well-designed instruction should not only encourage schema construction but also schema automation for those aspects of a task that are

consistent across problems (Merriënboer, Kirschner, & Kester, 2003). CLT is consistent with the finding of numerous studies on expertise which recognize experts' ability to retrieve information necessary to problem-solving with ease. Skill in the access, evaluation, and use of information and information systems reduces cognitive load in these processes and enable more working memory to be devoted to the processes involved in defining the information problem and the information perceived as necessary for solving it.

The research approach and strategies for inquiry are guided by this theoretical and conceptual framework, and matched to the research questions.

3.0 Chapter 3: Methodology

The ability to successfully answer questions, complete tasks, or solve problems requiring information seeking, search, use, or sharing behaviors is a common description of information literacy. Yet little is known about information problem-solving experts, how they think, or whether this expert thinking is transferable to new situations and new contexts. Literature from the cognitive sciences, the learning sciences, and library and information science indicates that skill in Task Definition is crucial to information problem-solving success. However, library and information science scholars have yet to apply corresponding theoretical insights to an empirical study of this proposition.

This research examined the nature and impact of Task Definition within the information problem-solving process. Specifically, this research seeks to determine how information problems are mentally represented and categorized by expert and novice information problem-solvers. The first investigation examined differences in the way that experts and novices categorize information problems in familiar and unfamiliar domains to determine whether

experts in information problem-solving behave similarly to experts in other domains, and whether this expert behavior transfers to novel domains. This study employed a quantitative approach in the collection and analysis of information problem categorization data. In the second investigation, participants were given a similar categorization task, and verbal reporting of their thought processes was recorded. This second study employed a qualitative approach to the collection and analysis of verbal reporting data, and seeks to determine how expert and novice information problem-solvers make categorical determinations. Taken together, these investigations seek to answer the questions of how information problems are categorized by experts and novices, and whether expertise is transferable across domains.

This chapter describes the methods used for the investigation of information problem categorization during Task Definition within the information problem-solving process employing the theoretical and conceptual framework described in Chapter 2. Included in this chapter are the rationale for the research design, descriptions of data collection and analysis, ethical considerations and strategies adopted for ensuring research quality, and a review of the research questions drawn from the problem space revealed in Chapter 1.

3.1 Introduction

- *What is the justification for this research?*
- *Which hypotheses will be tested?*

Within the field of library and information science, the domain of human information behavior is concerned with information needs, seeking, search, and use (Wilson 1999). The study of information literacy is concerned with effective behaviors in each of these areas and may be operationalized as the skills and stages of the information problem-solving process. The value of

information literacy has been established in scholarly literatures (Bruce, 1997; Chevillotte, 2010), professional practice (ACRL, 2008; ALA, 1989), pedagogy (Grassian & Kaplowitz, 2009; Julien, 2005), and Presidential Proclamation (Obama, 2009). This research seeks to fill the gap in our understanding of the cognitive processes involved in Task Definition during the information problem-solving process.

Empirical work in the cognitive sciences, learning sciences, and library and information science suggests that Task Definition, within the context of the entire information problem-solving process, is crucial to success. The Big6 information literacy approach to information problem-solving (Eisenberg & Berkowitz, 1990) identifies Task Definition as the initial stage of the process, which includes both the cognitive processes involved in defining the problem, and those involved in identifying information needs. During the process of Task Definition, the problem is mentally represented and categorized according to conceptual frameworks, or schemas. The information problem-solver's schema will determine strategies that will be executed at each subsequent stage of the process. Domain experts are more successful problem-solvers than domain novices because their domain knowledge is structured differently (Bransford, Brown, & Cocking, 2000; Sweller, 1988). Domain experts mentally represent problems and categorize them differently than do domain novices according to these structures; specifically, domain experts tend to categorize problems based on deeper structural features of problems rather than surface features (Chi, Feltovich, & Glaser, 1981; Hardiman, Dufresne, & Mestre, 1989).

A review of the literature on information literacy suggests that 1) the way we define and categorize a task guides subsequent solution strategies, 2) the more accurately we define a task, the more efficient and effective we will be in solving it, and 3) general information problem-solving strategies are transferable to novel problems and domains. This research seeks to identify

expertise in information problem-solving, the nature and impact of expert information problem-solving thinking, and the transfer of information problem-solving expertise.

This study was guided by the following overarching research question:

Overarching Research Question: What is the nature and impact of Task Definition in terms of information problem categorization within the information problem-solving process?

The following are the research questions related to this overarching question:

1. How do experts and novices in the domain of librarianship categorize domain-related information problems?

1.1. Specifically, how does the recognition and use of surface or deeper structural features in information problem categorization vary as a function of experience within the domain of librarianship?

1.2. How does the categorization by experts in the domain of librarianship compare to categorization by experts in other domains?

2. How do experts and novices in the domain of librarianship categorize information problems in domains other than librarianship?

2.1. Specifically, does expertise in the domain of librarianship result in the recognition and use of surface or deeper structural features in information problem categorization in novel domains?

2.2. Why does the categorization by experts in the domain of librarianship transfer or fail to transfer to other domains?

In order to identify expertise in information problem-solving, this research first investigated the differences between experts in information problem-solving and novices in the categorization of information problems in the domain of librarianship. The first hypothesis proposed by this research is:

- (H1) Experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition.

This hypothesis corresponds to the first research sub-question (RQ1.1). It was expected that domain experts in information problem-solving, operationalized in this investigation as experienced reference librarians, would recognize the deeper structural features of information problems within their domain of librarianship because this is what experts do in other domains. However, a direct comparison has yet to be made. Therefore, the second hypothesis corresponds to RQ 1.2:

- (H2) The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.

The first hypothesis (H1) was examined in Investigation 1 with a sorting method used in a number of studies to determine the cognitive processes engaged in the initial stage of problem categorization, the triad judgment task. This hypothesis was examined through the quantitative collection and analysis of the data in the triad judgment task. The second hypothesis (H2) was examined through the qualitative collection and analysis of data collected in Investigation 2, a sorting task eliciting the thinking process of the participant via the Repertory Grid (RepGrid) Technique.

Expert knowledge within a particular domain is structured differently than the knowledge of novices. Experts have more complex and robust problem schemas and tend to categorize problems based upon the deeper structural features of problems enabling the access to successful solution strategies. Although it is clear that expert problem-solvers benefit from domain-specific knowledge, it has yet to be determined the degree to which domain-general knowledge plays a role. This research also seeks to determine if information literacy is a type of knowledge that contributes to successful information problem-solving across domains. The transfer of information literacy skills to novel problems and domains is inherently assumed in information literacy research and programming, but remains untested. Definitions and descriptions of information literacy suggest that these skills are domain-general rather than domain-specific and may be applied successfully across domains (AASL/AECT, 1998; ACRL, 2008). According to Fields (2006): “Librarians are usually considered experts in general and sometimes subject-specific information literacy domains. They may or may not be more expert than the student in terms of the primary subject domain, however” (p. 413). Bates (1999; Pettigrew, Fidel, & Bruce, 2001) proposes that the field of information science is a meta-science, that is, research and practice in the field is oriented toward the representation and organization of information rather than the knowing of information. This proposition seemingly supports a domain-general skill approach. Empirical work in the field remains inconclusive (Head & Eisenberg, 2009a, 2009b, 2010b; Lloyd, 2005, 2007b, 2009; Lloyd & Williamson, 2008).

The cognitive sciences and the learning sciences host similar and longstanding debates. Smith (1991), in proposing a unified theory of problem-solving, recognizes the role of domain-specific knowledge in successful problem-solving, but also identifies general problem-solving knowledge as an important factor. However, research in the cognitive sciences reveals that domain experts

are not consistent in their ability to transfer their skills to novel situations and domains (Bernardo, 2001; Didierjean, 2003; Hatano & Oura, 2003; Inagaki, 1986; Mayer, 1998; Mayer & Wittrock, 1996; Novick & Hmelo, 1994). While research in the cognitive sciences makes it clear that the domain-specific background knowledge of domain experts is important in successful problem-solving, it is unclear the degree to which domain-general process skills knowledge may play a role (Rabinowitz & Hogan, 2008; Smith, 1991).

Therefore, the focus of both investigations then shifted to determining significant differences in problem categorization when novel domain content is introduced, for the purpose of determining the domain-generality of information problem-solving skills. The third hypothesis examined by this investigation corresponds to RQ 2.1:

- (H3) Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.

Information problem-solving skills are assumed to be domain-general as they are characterized in profiles of information literacy; that is, they transfer to novel problems and domains.

However, this proposition has yet to be tested. Therefore, the fourth hypothesis corresponds to RQ 2.2:

- (H4) The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains.

The third hypothesis was tested in Investigation 1 through a quantitative analysis of data collected through the triad judgment task, where tasks were presented from the domains of

everyday life and statistics. The fourth hypothesis was tested through qualitative analysis of data collected through Investigation 2.

3.2 Research Design Rationale and Assumptions

- *What are the most appropriate methods for investigating the research questions?*
- *Which assumptions are being made?*

In cognitive science research, there have been two approaches to examining the nature of expertise (Chi, 2006b): 1) studying the performance of experts on familiar tasks; that is, tasks typically undertaken within their domain of expertise, and 2) studying performance on contrived tasks, which are tasks not typically undertaken. The latter approach was appropriate for investigating the research questions identified in Chapter 1 for several reasons. For one, performance on contrived tasks reveal the thought processes of the individual, since novices may perform a contrived task just as successfully as an expert; likely, the familiar task would simply show that the expert could perform it faster and more accurately than the novice. For another, a contrived task may be designed to elicit behavior and reflection related to a particular and focused set of cognitive processes, in this case those engaged in Task Definition. Moreover, contrived tasks may be performed within a laboratory setting; cognitive processes engaged in performing familiar tasks in a more naturalistic environment are difficult to isolate, and may be confounded by external stimuli.

Hoffman (1995) describes types of contrived tasks that have typically been employed in the study of expert knowledge: recall, perceiving, sorting, and verbal reporting. Weiss & Shanteau (Weiss & Shanteau, 2003) also suggest a method for investigating expertise. Of these, categorizing is the best match for the purposes of this study, and has been used in several

significant studies (Chi et al., 1981; Dufresne et al., 1992; Hardiman et al., 1989; Hogan & Rabinowitz, 2009; Rabinowitz & Hogan, 2008; Shafto & Coley, 2003). This study took an experimental approach, enabling the researcher to test the hypotheses stated above.

The Triad Judgment Task

The first method employed in this research, a sorting task used in the seminal study by Chi et al (1981) and modified by Hardiman, Dufresne & Mestre (1989) and called the triad judgment task, was appropriate for examining the research questions in this study. This method enabled the researcher to focus on the cognitive processes related to Task Definition. Previous studies employing this method have revealed significant differences in ways that experts and novices categorize problems within a particular content domain (Dufresne et al., 1992; Hardiman et al., 1989; Hogan & Rabinowitz, 2009; Quilici & Mayer, 1996, 2002; Rabinowitz & Hogan, 2008). These studies constructed task problems that varied according to surface or deeper structural features related to a particular domain of knowledge. As studies conducted outside the field of library and information science, they were not concerned with the information that participants perceived as necessary to solve the task problems, however.

The triad judgment task is a categorizing task used to highlight differences between domain experts and novices in the way they categorize problems based upon surface or deeper structural features. A typical sorting task does not allow the research to vary the contrast set. In the triad judgment task, the research can contrast analog scenarios with surface feature versus deep structural feature similarities, those with deep structural feature versus no similarities, etc. This method was employed in the domains of engineering (Hardiman et al, 1989), statistics (Rabinowitz & Hogan, 2008), and teaching (Hogan & Rabinowitz, 2009). This method is well-

established and well-suited to an examination of Task Definition; more specifically, the categorization of information problems based upon surface or deeper structural features during Task Definition within the process of information problem-solving.

The triad judgment task involves a comparison between a target problem and two analog problems. An analog is a particular type of problem that is recognized by the problem-solver and cognitively encoded via schema. Generally speaking, an analog of a problem type will share with other analogs either problem objects in the case of similar surface features, object relations in the case of similar deeper structural features, or both. A near analog is one in which both surface and deep features are similar to a source problem, a remote analog is one in which only deeper structural features are similar to a source problem, and a distractor analog is one in which only surface features are similar to a source problem. A problem that does not share either set of features is not an analog (Gick & Holyoak, 1983). Comparison of a target problem to an analog problem that is a near analog is merely replication. Comparison of a target problem to an analog problem that is a remote analog is necessary to note differences between experts and novices. Comparison of a target problem to an analog problem that is a distractor analog may not distinguish, as both experts and novices will at times use surface features as these may be related to some degree to solution strategies (Novick, 1988).

Based upon findings in the cognate literature, the researcher hypothesized that participants with more experience in a given domain will tend to choose the analog problem with matching deeper structural features more often than those with less experience; those with less experience will tend to choose those analog problems with matching surface features more often. In Triad Comparison 1, one analog problem matched the target problem only in surface features, and the other matched the target problem only in deeper structural features. In Triad Comparison 2, one

analog problem matched the target problem only in surface features, and the other did not match the target problem in either feature; and in Triad Comparison 3, one analog problem matched the target problem only in deeper structural features, and the other analog problem did not match the target problem in either feature. The three Triad Comparisons enabled the assessment of participants' choice of feature when task demands were a factor. In this way, significant differences between experts and novices in problem categorization within each content domain were tested.

In previous studies in which this method was employed, the goal was to assess whether the focus on surface or deeper structural features varied as a function of experience within a particular domain. In this study, participants grouped as either novice or expert in the domain of librarianship performed a series of domain-related triad judgment tasks. Quantitative analysis of the data determined whether the participant categorized the given information problems based upon surface features or deeper structural features. In Investigation 1, data from expert and novice participant performance was analyzed to test the first hypothesis (H1).

In the second round of triad judgment tasks, participants performed a series of triad judgment tasks in two different domains—one “near” domain, and one “far” domain (Mayer & Wittrock, 1996). Everyday life situations served as the near, more familiar, domain and the domain of statistics served as the far, less familiar, domain (Bates, 1999). Again, data was collected and analyzed to determine whether the participant categorized the information problems according to surface features or deeper structural features. While all participants may be characterized as novices in the domain of statistics, verified by self-evaluation of statistics expertise in the Participant Description Survey, differences in categorization between librarianship novices and experts were examined. Similarly, while all participants may be considered “experts” in the

domain of everyday life situations, differences in the way that those trained and experienced in solving information problems (librarians) versus those who have not were examined. In this way, the proposition of the domain-general nature and impact of information literacy skills was examined. Quantitative analysis of the data from expert and novice participant performance was analyzed to test the third hypothesis (H3).

The Repertory Grid Technique

The Repertory Grid (RepGrid) Technique (George Kelly, 1955) was employed in the second investigation to elicit the thought processes of participants during a sorting task. The RepGrid Technique was developed by psychologist George Kelly (Kelly, 1955). Kelly theorized that people construct knowledge by testing personal hypotheses about the world around them, and modifying understandings based upon behavior outcomes. Thus, at any point in time, an individual will have a system of personal constructs about the elements in their environment. The RepGrid Technique has been described as a “cognitive mapping technique that attempts to describe how people think about the phenomena in their world” (Tan & Hunter, 2002, p. 40); uses include the study of expert systems manager qualities (Hunter, 1997) and features of an expert customer support system (Phythian & King, 1992). The RepGrid Technique was employed in this investigation to reveal the cognitive processes of participants during categorization of information problems.

The goal of the RepGrid Technique is to reveal the participant’s system of personal constructs about the elements in their environment . For the purposes of this investigation, an element refers to a typical information problem found in a particular domain, a construct refers to the participant’s understanding of a particular information problem (that is, the nature of the

problem, and the information necessary to solve the problem), and a system of personal constructs refers to a schema a participant may have for the particular problem type. In addition to elements and constructs, the third major component of the RepGrid is links—these are ways in which elements and constructs are related. Further, these links “reveal the research participant’s interpretations of the similarities and differences between the elements and the constructs (Tan & Hunter, 2002, p. 43). The RepGrid Technique is efficient in yielding data tailored to a particular research question; typically, between 15 and 25 participants are sufficient to provide a complete set of data for analysis (Tan & Hunter, 2002)

RepGrid data will be analyzed qualitatively using analytic induction, a content analysis approach, to reveal patterns that emerge in participant categorization of information problems in three domains. Data collection will be conducted over a three-month period. The focus of the qualitative analysis will be to describe constructs that emerge in each participant group, and to indicate their relative importance. The researcher expects that this analysis will reveal the cognitive processes of participants during information problem categorization in multiple domains and test hypotheses 2 and 4:

- H2 (RQ 1.2): The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.
- H4 (RQ 2.2): The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains

Assumptions

Based upon evidence derived from the literature, the researcher made the following assumptions in the design of these investigations:

- Information literacy may be operationalized as the stages and skills necessary for successful information problem-solving.
- As described by the cognitive science literature, experts in certain domains are more successful problem-solvers than are domain novices; definitions of expert and novice were driven by the literature, but may be operationalized by the researcher as those with formal training and experience in the field of librarianship, and those without.
- The categorization of an encountered problem as a type previously resolved by the problem-solver suggests subsequent solution strategies.
- Ill-structured problems are different than well-structured problems, and engage a different set of cognitive processes during the problem-solving process. Information problems are typically not well-structured, as they require information not already within the knowledge base of the problem-solver, but should elicit similar categorization processes as the well-structured problems used in previous studies.
- Earlier findings about problem categorization, that experts tend to use deeper structural features and novices tend to use surface features of well-structured problems, will hold true for information problems, which are not well-structured.
- There is more than one set of skills that may affect performance in information problem-solving; skills may be characterized as domain-specific or domain-general.

Alignment of Research Question, Hypothesis, Method, and Analysis.

It was expected that these investigations would deepen our understanding of information literacy. The goal of these investigations was to examine the nature and impact of successful information problem-solving; this was accomplished by investigating the categorization of experts and novices in the domain of librarianship, and the transfer of information problem-solving skills to novel domains.

The research questions were examined through two investigations. Investigation 1 (Inv1) examined the categorization of domain-related information problems based upon either surface or deeper structural features by experts and novices in the domain of librarianship, and then in the near domain of everyday life situations, and the far domain of statistics. Investigation 2 (Inv2) employed the RepGrid Technique to elicit the thought processes of experts and novices in the categorization of information problems.

Table 3.1 presents the alignment between the research questions, related hypotheses, the methods employed to test these hypotheses, and the subsequent analysis of collected data.

Research Question	Hypothesis	Method	Analysis
RQ 1.1 Specifically, how does the recognition and use of surface or deeper structural features in information problem categorization vary as a function of experience within the domain of librarianship?	H1 Experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition.	(Inv1: Round 1) Triad judgment task	Experimental, quantitative analysis, parametric (ANOVA)
RQ 1.2 How does the categorization by experts in the domain of librarianship compare to categorization by experts in other domains?	H2 The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.	(Inv2: Round 1) Sorting task via RepGrid Technique	Explanatory, qualitative analysis
RQ 2.1 Specifically, does expertise in the domain of librarianship result in the recognition and use of surface or deeper structural features in information problem categorization in near and far domains?	H3 Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.	(Inv1: Round 2) Triad judgment task	Experimental, quantitative analysis, parametric (ANOVA)

RQ 2.2 Why does the categorization by experts in the domain of librarianship transfer or fail to transfer to other domains?	H4 The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains.	(Inv2: Round 2) Sorting task via RepGrid Technique	Explanatory, qualitative analysis
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Table 3.1: Alignment of research question, hypothesis, method, and analysis.

3.3 Research Design

- *How were the instruments used developed and tested for validity?*
- *Who were the targeted participants and how were they recruited?*

The literature suggested these assumptions in the research design: 1) the way we define a task guides subsequent solution search strategies, 2) the more accurately we define a task, the more efficient and effective we will be in solving them, and 3) information problem-solving strategies are transferable.

Investigation 1, the online triad judgment tasks, tested hypotheses 1 and 3:

- H1 (RQ 1.1): Experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition.
- H3 (RQ 2.1): Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.

The follow-up investigation (Investigation 2), employing a sorting task and the Repertory Grid Technique, tested hypotheses 2 and 4:

- H2 (RQ 1.2): The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.

- H4 (RQ 2.2): The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains

3.3.1 Investigation Formats

This investigation was conducted online via tools available from the University of Washington (Catalyst WebQ). Participants were asked to complete a type of sorting task called the triad judgment task presented on successive screens. Participants were assigned to either expert or novice groups, and data was recorded electronically for analysis.

Given the limitations of the triad judgment task in examining the conscious rationale for information problem categorization, a follow-up investigation was designed to take a more in-depth look at the cognitive processes involved in the categorization of information problems. Participants from Investigation 1 met face-to-face with the researcher, and were asked to sort three sets of information problems according to the RepGrid Technique (Kelly, 1955). In this investigation, participants were assigned to either the expert or novice group according to assignments from Investigation 1; a third group was included, those without librarianship training or expertise, but with significant experience in a professional field. RepGrids were recorded for analysis, reflecting participant thinking during sorting tasks.

3.3.2 Development and Testing of Instruments

Information Problem Scenario Development

Information problem scenarios were developed for use in Investigations 1 and 2. The nature of an information problem may be described by a number of scales including perceived complexity

(Bystrom & Jarvelin, 1995), typology (Jonassen, 2000), context (Lloyd, 2005), and process stage (ACRL, 2008; Eisenberg & Berkowitz, 1988). The formula for generating information problem scenarios may easily become a complex endeavor.

In order to ensure a systematic and structured approach for the generation of information problem scenarios, the researcher designed a formula that focused on a stage in the process of information problem-solving as modeled by the Big6 information literacy approach. The formula held constant the perceived complexity to a Normal Information Processing Task (Bystrom & Jarvelin, 1995); that is, the type of information likely perceived as needed to complete the task is only partially a priori determinable, whereas the result or outcome is fully determinable. In other words, in this type of task, the information problem-solver will have a clear picture of the goal state, but may experience uncertainty about the information that will be needed and the solution strategies that may need to be implemented. The scenario formula also held constant the type of problem as described by Jonassen (2000) to a Decision-Making Problem.

The formula includes three levels of information (Bystrom & Jarvelin, 1995):

Level 1: Domain information, to include the domains of librarianship, statistics, and everyday life situations.

Level 2: Problem information, which relates to the context of the information problem in each domain, and serves as the surface features, or narrative of the information problem scenarios; the researcher ensured a balance of male and female protagonists in scenario narratives.

Level 3: Problem-solving information, which relates to strategies for problem treatment, and serves as the deeper structural features of the information problem scenarios. At Level 3, problem-solving information, three categories were selected. These categories are identified by

the ACRL Information Literacy Competency Standards for Higher Education (ACRL, 2008), and correspond to the Big6 information literacy approach (Eisenberg & Berkowitz, 1988). The ACRL Information Literacy Competency Standards for Higher Education guided the development of Project SAILS (Standardized Assessment of Information Literacy Skills) at Kent State University (SAILS, 2008). Three standards were selected to serve as problem-solving information categories. These standards categories are:

- Standard One: The information literate student determines the nature and extent of the information needed (TD=Task Definition)
- Standard Two: The information literate student accesses needed information effectively and efficiently (IA=Information Access)
- Standard Three: The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system (IE=Information Evaluation) (ACRL, 2008)

Thus, when problem information (Level 2) and problem-solving information (Level 3) are combined within each domain (Level 1), a total of 33 information problem scenarios were generated according to the formula (Tables 3.2A-3.2C). These were grouped to create the triad judgment task comparisons described in the next section.

Level 1: Domain Information: Librarianship (Set 1)		Level 2: Problem Information				
		Neighbor + Political Processes	Medical Professional + Health Information	College Student + US Electoral College	Elementary Student + Careers	High School Student + World War II Events
Level 3: Problem-	Task Definition (TD)	Scenario TD-1	Scenario TD-2	Scenario TD-3	Scenario TD-4	Scenario TD-5

Solving Information	Info Access (IA)	Scenario IA-1	Scenario IA-2	Scenario IA-3	Scenario IA-4	Scenario IA-5
	Info Evaluation (IE)	Scenario IE-1	Scenario IE-2	Scenario IE-3	Scenario IE-4	Scenario IE-5

Table 3.2A: Formula for Information Problem Scenario Generation (Librarianship)

Level 1: Domain Information: Everyday Life Situations (Set 2)		Level 2: Problem Information		
		Financial Systems	Travel Info	Consumer Advocacy
Level 3: Problem-Solving Information	Task Definition (TD)	Scenario TD-1	Scenario TD-2	Scenario TD-3
	Info Access (IA)	Scenario IA-1	Scenario IA-2	Scenario IA-3
	Info Evaluation (IE)	Scenario IE-1	Scenario IE-2	Scenario IE-3

Table 3.2B: Formula for Information Problem Scenario Generation (Everyday Life Situations)

Level 1: Domain Information: Statistics (Set 3)		Level 2: Problem Information		
		Psychology	Academia	Management
Level 3: Problem-Solving Information	t-test (t)	Scenario t-1	Scenario t-2	Scenario t-3
	Chi-square (x)	Scenario x-1	Scenario x-2	Scenario x-3
	Correlation (r)	Scenario r-1	Scenario r-2	Scenario r-3

Table 3.2C: Formula for Information Problem Scenario Generation (Statistics)

Two professionals currently in the practice of librarianship with ten or more years of experience were recruited by the researcher to review each information problem scenario in the domains of librarianship (Set 1), and Everyday Life Situations (Set 2). They were asked to first identify surface features for each of the 18 information problem scenarios, and then rate on a 5-point scale the clarity of surface features. This procedure was repeated with a focus on the deeper structural features. Each of the task problem scenarios included in Sets 1 and 2 scored an average of 4.0 or better on a scale of clarity by these raters on each of the focus areas: surface and deeper structural feature clarity. For Set 3 (statistics), information problem scenarios were selected from

those originally used by Quilici & Mayer (1996) in their study of the role of examples in students' categorization of statistics word problems, and later by Rabinowitz & Hogan (2008); permission was granted by the author to use these scenarios in this research (see Appendix B). See Appendix A for the full text of all information problem scenarios.

Triad Judgment Task Development

Sets of triad judgment tasks, composed of three information problem scenarios, were created—one was designated as the target problem, and two as analog problems. In the triad judgment task, the participant is presented with a target problem and two analog problems. The participant is then asked to choose the analog problem that “goes best” with the target. In the original study employing the triad judgment task (Hardiman et al, 1989), the researchers asked participants to select the problem that would be “solved similarly.” However, this phrase was adapted in subsequent studies (Rabinowitz & Hogan, 2008; Hogan & Rabinowitz, 2009) so as not to prime participants to search for the deeper structural feature.

Information problem scenarios serving as tasks were grouped according to a specified correspondence. Given a target problem, with a predetermined surface and deeper structural feature, each analog problem was either similar or dissimilar to the target problem's surface features, and similar or dissimilar to the target problem's deeper structural features. Adding cases in which an analog problem may have both or neither features similar to the target problem, there are six possible comparisons for each triad judgment task set (order does not matter). Table 3.3A below shows all possible comparisons; an analog problem that is similar in surface features only is represented by S, one that is similar in deeper structural features only is represented by D, one

that is similar in both surface and deeper structural features is represented by SD, and one that has no similar features is represented by N.

Triad Comparison	Analog Problem 1	Analog Problem 2
1	S	D
2	S	N
3	N	D
4*	S	SD
5*	D	SD
6*	N	SD

Table 3.3A: Possible Triad Judgment Task Comparisons

***Not the focus of this investigation**

This investigation examined comparisons in which each analog problem in the pair matched the target problem only in either surface or deeper structural features (Comparisons 1-3). The pairing involving an analog with both matching surface and deeper structural features was eliminated (Comparisons 4-6).

Studies suggest that there may be other factors affecting focus on either surface or deeper features, such as demands of the task and processing approach (Hardiman et al., 1989).

Moreover, previous studies have indicated that surface features will have an effect on the problem categorization of both expert and novice problem-solvers (Blessing & Ross, 1996). For the purpose of this investigation, however, the best choice of analog problem is the one with deeper structural similarity to the target problem.

Assignment of Scenarios to Triad

The next stage of development was to assign scenarios to each triad judgment task. Table 3.3B shows the three comparisons selected for this investigation.

Triad Comparison	Analog Task Problem 1	Analog Task Problem 2
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1	S	D
2	S	N
3	N	D

Table 3.3B: Triad Judgment Task Comparisons

Comparisons 1 and 3 (S-D and N-D) enabled an examination of categorization based on deeper structural features; Comparison 2 (S-N) enabled an examination of categorization based on surface features, and served to disrupt any priming (especially expert) participants may have had prior to participation.

The researcher conducted an analysis on the number of triad judgment tasks participants would be asked to complete, the length of time it would likely take to complete them, and the likelihood of completion of all tasks. The researcher determined that 30 triad judgment tasks could be completed between 30-45 minutes. This calculation optimized the number of tasks that would yield an adequate amount of data, an amount of time perceived by participants to be acceptable for participation in the study, and the likelihood that participants would complete all tasks once they had begun.

The researcher determined that all three triad judgment tasks comparisons would be included in the domain of librarianship (S-D, S-N, N-D), but that only the first comparison, S-D, would be included in the domains of everyday life and statistics. This determination satisfied the requirements of the research questions. Therefore, for the domain of librarianship, participants were given six different iterations of each comparison, for a total of 18 triad judgment tasks; this was round 1.

The next step was to assign particular scenarios to each of the 18 triad judgment tasks. Scenarios were assigned as either a target or one of two analog problems according to controlled random assignment. The researcher verified that no scenario appeared as a target more than twice, and

that all scenarios appeared as a target or an analog in equal measure. In other words, triads were formed randomly, and ordered randomly according to an arranged structure:

1. The domain of librarianship information problem scenarios were presented first, then the domain of everyday life situations, then statistics.
2. An N-S comparison type task was presented first to avoid test priming, then N-D, then S-D; this rotation continued until 18 triad judgment tasks were assigned.
3. For the other domains, this rotation continued until 6 triad judgment tasks were assigned, since only the S-D comparison type was included.
4. For each triad judgment task, the D principle in the target scenario was rotated as follows:
TD, IA, IE.

Table 3.4A shows the final assignments.

TJT Comparison	Target Problem	Analog Problem 1	Analog Problem 2
1 (S-D)	TD-1	IA-1	TD-5
	TD-3	IE-3	TD-4
	IA-1	IE-1	IA-5
	IA-5	TD-5	IA-3
	IE-1	TD-1	IE-4
	IE-2	IA-2	IE-5
2 (S-N)	TD-1	IA-1	IA-2
	TD-4	IE-4	IA-3
	IA-3	IE-3	IE-4
	IA-5	TD-5	IE-2
	IE-2	TD-2	TD-5
	IE-5	IA-5	TD-4
3 (D-N)	TD-3	TD-2	IA-1
	TD-2	TD-1	IE-5
	IA-3	IA-5	TD-4
	IA-4	IA-2	IE-4
	IE-3	IE-1	IA-2
	IE-4	IE-2	TD-5

Table 3.4A: Scenario Assignments in the Domain of Librarianship

For the second round, triad judgment tasks related to the domains of everyday life information and statistics, participants were given six different iterations of comparison 1 only (S-D), for a total of 6 triad judgment tasks within the domain of everyday life information, and also 6 triad judgment tasks within the domain of statistics. Comparison 1 offered the clearest test of preference between surface and deeper structural features in the categorization of information problems. The controlled randomization process was repeated for each of the triad comparisons for these domains. In all, participants were given 30 triad judgment tasks. Tables 3.4B and 3.4C show these assignments.

TJT Comparison	Target Problem	Analog Problem 1	Analog Problem 2
1 (S-D)	TD-2	IA-2	TD-1
	TD-3	IE-3	TD-2
	IA-1	TD-1	IA-3
	IA-2	IE-2	IA-1
	IE-2	IA-2	IE-3
	IE-3	TD-3	IE-1

Table 3.4B: Scenario Assignments in the Domain of Everyday Life Information

TJT Comparison	Target Problem	Analog Problem 1	Analog Problem 2
1 (S-D)	t-2	r-2	t-1
	t-3	x-3	t-2
	x-1	r-1	x-3
	x-2	r-2	x-1
	r-2	x-2	r-3
	r-3	t-3	r-1

Table 3.4C: Scenario Assignments in the Domain of Statistics

Building of Online Triad Judgment Task Instrument

The online triad judgment task instrument was built using Catalyst WebQ, a secure and reliable online survey tool available to faculty and students at the University of Washington. Although scenarios were assigned to triad judgment task comparisons randomly, further randomization

procedures were followed with regard to how participants would be presented the succession of triad judgment tasks:

1. Context scenarios presented in succession--all librarianship comparisons presented first, then everyday life, then statistics.
2. “Best” choices, or those with a deeper structural feature similarity, were balanced for selection A or B.
3. Three S-N comparisons were presented first to deter task priming and disrupt pattern recognition, then three D-N and three S-D, and so on.
4. Within comparison type sets, tasks were balanced by deeper structural feature in target (TD, then IA, then IE, and so on)

The instrument was completed on April 26, 2015.

Experimental Procedures for Investigation 1

This investigation was conducted online. The following procedures describe the participant experience:

1. Participants were invited to participate in the study, and provided a link to access the online triad judgment tasks (tinyurl.com/problemsort).
2. Participants are first welcomed to the study, given a brief overview of the tasks, and invited to participate in a drawing for a gift card as an acknowledgment of their time spent on participation.
3. Participants are then asked to complete the informed consent process; although this study received an exempt status from the Institutional Review Board/Human Subjects Division, the researcher adopted informed consent procedures for both investigations.

4. Each of the next thirty screens are triad judgment tasks, 18 composed of scenarios related to the domain of librarianship, and 12 composed of scenarios related to the domains of everyday life information and statistics (6 each).
5. Participants completing the online decision tasks were asked to complete a Participant Description Survey to gather demographic data.
6. Participants were then asked to serve as participants in Investigation 2, and were prompted to provide contact information.
7. Finally, participants were invited to provide contact information and participate in a drawing for gift cards as an acknowledgment of their time.

Data collection was conducted over a six-month period in the fall of 2015 and the spring of 2016. See Appendix C for the full text of the instrument; see Appendix D for the Catalyst tool summary window. Data is analyzed and hypotheses are tested using the ANOVA as was used in numerous studies employing this method (Quilici 1996, 2002; Hogan 2009; Rabinowotiz 2008; Hardiman 1989)

Building of Sorting Task and RepGrid Technique Instrument

The Repertory Grid (RepGrid) Technique (George Kelly, 1955) was employed in the second investigation to elicit the thought processes of participants during a sorting task. For this second investigation, participants were asked to randomly draw three scenario cards from those developed for the first investigation. Card sets were presented sequentially: Set 1 (domain of librarianship) was presented for sorting first, then Set 2 (domain of everyday life information), and finally Set 3 (statistics). They were then asked to select two that “were more similar to each other” than the third and offer a concise phrase for their selection. If the response did not indicate

a clear reason, the researcher would use a laddering technique to arrive at a concise statement of similarity. This statement was recorded on the RepGrid form. Then, the participant was asked to explain why the third scenario “was different from the first two,” and the laddering process was again used to arrive at a concise statement. Again, this statement was recorded on the RepGrid form so that the two statements represented a binary condition. The analysis of these responses enabled the researcher to determine the conscious rationale participants applied to the categorization of information problems. The RepGrid Technique has been used to study cognition in a number of studies (Tan & Hunter, 2002) both qualitative (Hunter, 1997) and quantitative (Phythian & King, 1992). This method is a structured approach to the sorting task designed to test hypotheses 2 (H2) and 4 (H4) via focus on participant categorization constructs. Table 3.7 shows the format for the RepGrid form where participant data was recorded.

Sort	Elements			Constructs	
	1	2	3	Why 2 Similar?	Why 3 rd Different?
1					
2					
3					
...					

Table 3.7: RepGrid Data Collection Form

Experimental Procedures for Investigation 2

In this investigation, participants met face-to-face with the researcher at a convenient location.

The following procedures were followed with each participant:

1. Participant was welcomed and asked to complete the informed consent process (reading of the Participant Information Sheet and verbal agreement of participation).
2. Instructions for the sorting task were read to participant.
3. Participant was asked to select three cards from Set 1 (Librarianship) at random, read the scenarios, and then select two that were “more similar” than the third.
4. The researcher engaged the participant in a laddering process until a concise statement of similarity was determined; this statement was recorded on the RepGrid form.
5. The participant was then asked to describe how the third scenario was different from the first two, and this statement was recorded; if necessary, a laddering process was engaged.
6. Upon collection of the three scenario cards, scenario identification numbers were recorded on the RepGrid form.
7. This procedure was repeated for Sets 2 (Everyday Life Information) and Set 3 (Statistics).
8. Participant was thanked for their time and offered a gift card or equivalent.

RepGrid Technique Laddering Process

After three scenario cards are selected randomly from the pile, the participant is initially asked, “How are two of the three scenarios similar to one another?” Further questions asked are designed only to identify the concise criterion construct, employing a laddering up approach if it is necessary to move up from the specific descriptive level, or a laddering down approach if it is necessary to move down from an overly-general evaluative level. Probing questions were drawn from the following list:

- “Tell me what you mean by...”
- “Give me an example of...”
- “How would one recognize this characteristic of...”
- “Is there a particular important aspect of...”
- “How do you know...”
- “In which way is it different...”
- “What evidence can you give...”

Next, the participant is asked, “How is the third scenario different?” This process is used to reveal the bipolar criterion construct used to sort the scenario cards. A subsequent content analysis method was applied to data collected from this phase of the research. According to this method, analytic induction, the personal constructs collected from participants are first examined through the lens of the researcher’s theoretical framework, and then the data is reexamined to identify new patterns or understandings (Patton, 2002). In this research, the researcher first looked for patterns related to surface narratives and underlying principles, including stages in the information problem-solving process as described by the Big6. A second review sought to uncover patterns and understandings previously undiscovered.

See Appendix G for the full text of the Investigation 2 protocol.

Pilot Testing

Prior to formal participant recruitment, the online triad judgment tasks were evaluated on the following criteria in the summer of 2015:

1. Ease of access.

2. Clarity of instructions and description of the study.
3. Time required to complete all tasks.
4. Preliminary data corroborating the accuracy of hypotheses.

Initially, twelve participants agreed to pilot test the online triad judgment task; ten reported no librarianship experience and were categorized as novices (n=13), and two reported significant librarianship experience and categorized as experts (n=2). Six of the participants were recruited from undergraduate courses at the University of Washington taught in the summer quarter of 2015, and were unfamiliar with the researcher; six were associated with the researcher and were recruited out of convenience. Three more were recruited at the midpoint of the study between novice and expert recruitment in the winter of 2016. Each was asked to complete the online judgment tasks and provide feedback on the four criteria.

Ease of use: All (n=15) reported that the instrument was easy to access with a provided link, and easy to navigate.

Clarity of instructions and description of the study: All reported (n=15) that the description of the study included in the opening screen was sufficient; the researcher provided a broad overview of the intent of the study that would not instill pre-test bias. Several participants requested clarity on the directions to select the analog scenario that “goes best” with the target; however, the researcher did not offer this clarification—this phrase is a key component of the research design. Researchers employing this method (Rabinowitz & Hogan, 2008; Hogan & Rabinowitz, 2009) expected that any other phrase would prime participants to search for deeper structural features.

Time required to complete all tasks: Several participants (n=7) reported that completion of the tasks felt time-consuming, and averaged 45 minutes or more to complete. The researcher added the following sentence to the text of the instructions to encourage participants to make intuitive selections and move quickly through the tasks:

“You are encouraged to move quickly through the decision tasks; the time for completion of all decision tasks should be less than 30 minutes.”

The researcher expected that intuitive selections would result in data that would more accurately reflect categorical thinking. See Appendix C for the final text of the triad judgment task instructions after pilot testing.

Preliminary data corroborating the accuracy of hypotheses: Descriptive statistics were generated from the pilot participant data, and analyzed in an effort to corroborate the accuracy of hypotheses. The researcher expected that experts in librarianship would tend to select the analog scenario that was similar to the target based on deeper structural features, and that novices would tend to make selections based on surface features. Scores were calculated based on participant selection of the “best” choice in each triad judgment task; that is, selection of the analog with a deeper structural feature similarity to the target.

Within the domain of librarianship, there were two comparisons that offered an analog with a deeper structural similarity to the target: comparison S-D and comparison N-D. In both comparisons, expert participants selected the analog with the deeper structural feature similarity more frequently than did novices, 83% to 56%, and 67% to 37%. Within the domain of everyday life information, where the researcher hypothesized that the familiar context would result in similar frequencies of deeper structural feature selection between experts and novices, the results

were similar: 50% to 45%. Within the third domain of statistics, where the researcher expected that both groups would select surface features due to the unfamiliar content, experts still selected deeper structural feature matches more frequently than novices 42% to 24%.

Comparison Type	Domain	Librarianship Expertise	
		Novice	Expert
N-D	Librarianship	56%	83%
S-D	Librarianship	37%	67%
S-D	Everyday Life Info	45%	50%
S-D	Statistics	24%	42%
S-N	Librarianship	90%	92%

Table 3.5: Pilot Testing Results

During pilot testing, it was discovered that there was an error in one of the comparisons: one of the N-D comparisons was actually an S-D comparison. The incorrect analog scenario was replaced and the error was corrected (Question 14).

These results corroborated researcher expectations, and suggested that the instrument was a valid measure of information problem categorization differences based on librarianship expertise.

The follow-up investigation, Investigation 2, was piloted with two participants who are associates of the researcher during April of 2016. Both the protocol and instrument were deemed valid.

Human Subjects Review

Documentation of a proposal for this research study was submitted to the University of Washington Institutional Review Board on July 20, 2015. The researcher requested exempt status under Category 7; this exempt status was granted on August 12, 2015, and was given HSD Reference #50222.

3.3.3 Participant Recruitment

Experts in information problem-solving are operationalized as experienced reference librarians. As rationalized in Chapter 2, experienced reference librarians have been trained in the content knowledge and pedagogical content knowledge of the domain of librarianship (L. S. Shulman, 2000). Content knowledge will include the nature of information sources (which contain information) and channels (that guide the user to relevant sources), as well as the organization of information sources, channels, and the information within sources (Bystrom & Jarvelin, 1995). Through practice, reference librarians also develop an understanding of the classifications of information types (problem information, domain information, and problem-solving information) and problem types. Problems presented to reference librarians may be classified according to perceived complexity (Bystrom & Jarvelin, 1995) and typology (Jonassen, 2000). Through practice, these librarians also develop pedagogical content knowledge; that is, the ability to effectively convey to the user an understanding of content knowledge through a variety of methods. The researcher assumes that individuals completing an accredited program in library and information science, and then practicing in any context calling upon this preparation will have had experience in applying the process skills of solving information problems in one or more content areas.

Typically, the length of time deemed necessary to develop expertise within a particular domain is 10 or more years (Hayes, 1981). Ericsson (Ericsson & et al., 1993) makes the claim that it takes 10,000 hours (20 hours for 50 weeks a year for ten years = 10,000) of deliberate practice to become an expert in almost anything. The researcher has approximated this level of expertise by recruiting librarians currently in practice in Washington State; the achievement of a Master's in Library and Information Science, typically a requirement for employment in a public or

academic library setting, implies at least six years of experience with academic library services, two of which are focused on the theoretical and conceptual foundations of library science. It was expected that that the remainder of the time recognized for attaining expertise came from years in practice.

For Investigation 1, a stratified purposeful sampling strategy was applied to the recruitment effort; participants were categorized as either novices or experts in the library field. Novices were recruited using a convenience sampling technique from the pool of students enrolled in an undergraduate degree program at the University of Washington with no prior librarianship training or experience; instructors of undergraduate courses taught through the Information School were contacted by the researcher. Three instructors agreed to allow the researcher or an associate to briefly explain the intent of the research study and to post a link to the online triad judgment tasks in the fall quarter of 2015. Moreover, the instructor of an undergraduate statistics course agreed to announce the study and provide a link to students in the same quarter. A second novice recruitment effort was made via direct email to undergraduate students in the Informatics program in the Information School in the spring quarter of 2016.

Experienced librarians were recruited from the population of practicing librarians in Washington State in public, K-12, academic, and corporate library settings. A database of all personnel listed in the Washington State Library (<http://www.sos.wa.gov/library/>) was generated; all job titles which suggested reference service were included. Levels and contexts of experience supplied by participants in the Participant Description Survey enabled experience comparisons, and verification of group assignments. See Table 3.6 for the timeline of recruiting participants for Investigation 1. See Appendix F for the text of messages used for recruitment of both groups.

Source	Grouping Target	Date of Request	Method	Number of Responses
INFO200	Novice	10/26/15	Classroom pitch + Class email	28
PSYCH317	Novice	11/3/15	Email via instructor	13
INFO101	Novice	11/6/15	Classroom pitch + Class email	22
INFO102	Novice	11/9/15	Classroom pitch + Class email	-
WA Public + Academic Library Staff Database	Expert	4/8/16	Direct email	112
WLMA Online Newsletter	Expert	4/19/16	Link in WLMA online newsletter	20
Informatics DL + Facebook Page	Novice	4/25/16	Direct email + Facebook page post	13
Total				208

Table 3.6: Investigation 1 Participant Recruitment Timeline

For the follow-up study, Investigation 2, participants were drawn from the pool of participants recruited for Investigation 1 and indicating an interest in further participation. While there is no rule for sample size in qualitative inquiry (Patton, 2002), the researcher determined that a 10% sub-sample would be recruited. Direct email contact was made during May and June of 2016, beginning with those who had most recently completed the online judgment tasks. The researcher judged that these participants would be more amenable to participate further than those who had completed the tasks several months before. The researcher contacted 5 participants from each of the sample groups at a time, employing a snowball sampling technique, until the requisite number of interviews had been reached. In all, 10 participants from each group were interviewed for a total of 20 participants from the 208 who participated agreed to participate in Investigation 2. An additional 10 participants were recruited using a convenience sampling technique during this time frame representing an exploratory sample group of those

without librarianship training or experience, but with significant professional experience. See Appendix F for text of recruitment message for Investigation 2.

Participant Token of Appreciation

As a token of appreciation for time spent on completion of all triad judgment tasks, participants were invited to participate in drawings. The text included in the online triad judgment tasks welcome screen during the period of novice recruitment (October 3, 2015 to April 7, 2016) stated: “Completion of all decision tasks enters you in a drawing for a \$50 Amazon gift card; a gift card will be awarded for every 10 participants.” A randomization procedure was applied during this recruitment window, and eight Amazon gift cards were awarded to participants (from a total of 78 novice participants).

The text included on the online triad judgment tasks welcome screen during the period of expert recruitment (April 8, 2016 to May 14, 2016) stated: “Participation and completion of the entire exercise enters you in a drawing for one of several \$50 Amazon gift cards.” A randomization procedure was applied during this recruitment window, and five Amazon gift cards were awarded to participants (from a total of 130 expert participants).

For Investigation 2, each participant was offered a \$30 Amazon gift card or equivalent.

Participant Description Survey

In Investigation 1, each participant was asked to supply the following demographic information after the online triad judgment tasks were completed:

- Age
- Gender

- Education
- English fluency
- Librarianship experience
- Setting of library experience
- Statistics experience

Participants were reminded that this information would be confidential and could not be used to identify them. This information was used to determine correlations, which is presented in Chapter 4. While participants were initially assigned to sample groups according to the time frame in which they were recruited, this demographic information (librarianship experience) was used to verify the accuracy of sample group assignment in both investigations. See Appendix E for the full text of the Participant Description Survey.

3.4 Ethical considerations and Ensuring Research Quality

- *How will measures of validity be determined?*

The rigor of this research in terms of design, execution, and analysis will be determined by measures of validity. In this section, internal validity, construct validity, statistical validity, and external validity are discussed.

Internal Validity

Internal validity is concerned with the causal relationship between defined elements in the investigation; in other words, is there evidence of a relationship between variables? This research is designed to focus on the relationship between expertise in information problem-solving and categorical determinations.

A possible concern with an experimental design that assigns participants to groups based upon a predetermined characteristic, such as the quasi-experimental design used here, is that it introduces uncertainty as to the causal relationship between an effect and its identified cause. Threats to internal validity certainly exist with the modifications made to adapt selected methods; the theoretical framework constructed for this research addresses these threats.

- Sampling technique applied in recruitment of novice participants in phase 2 may have yielded skewed results.

Construct Validity

Construct validity is concerned with the degree to which inferences may be made from the operationalizations developed for this investigation based upon the theoretical background identified in Chapter 2 (Creswell, 2003; Krathwohl, 1993). In other words, is the design grounded in the theoretical framework?

- Domains included in this research may not be representative of actual domains in which transfer may occur.
- Method has been applied to well-structured problems in prior research; information problems are not well-structured, and introduce noise into the data.
- Operationalizing of domain scenarios
- Deeper structural features = Big6 stages
- IPS experts as trained librarians
- Expertise resulting in categorical determination based on deeper structural features
- Age: this may be a confound, as life experience may affect the degree to which a person makes categorical determinations based on deeper structural features of a problem

situation. The construct of novice is more effective for the goals of this investigation to recruit participants who will not have had the opportunity to develop librarianship skills in professional experiences; recruiting young adults serves the aim of this goal. However, to counterbalance the possible confounding effect of age, a target sample size will be set to 100. Moreover, an analysis of covariance will be run in the data analysis to determine the effect of age.

Reliability (Statistical Validity)

Strategies to address reliability concerns have been integrated into the research design, including the review of information problem scenarios by experts and novices for identifiable surface and deeper structural features, and piloting of triad judgment tasks with experts and novices for comparison type outcomes, as well as test fatigue.

- Catalyst WebQ tool cannot determine if a participant completed the tasks more than once. A check was made of the email addresses provided by participants, and there were no repeats. However, it is impossible to determine if a participant completed the tasks more than once, providing a different email address each time.
- SPSS statistical software was used to conduct statistical tests.

External Validity/Generalizability

External validity is a measure of the degree to which phenomena in the real world may be predicted by the findings of this research; in other words, does the relationship extend beyond the study?

The choice of an experimental research design to be conducted online compromises the external validity of study findings, and subjects the generalizability of study findings to criticism.

However, given the precisely-defined set of cognitive processes under study, this approach yields the most robust construct validity. Thus, an inevitable tradeoff must be wagered.

- As a contrived task, the triad judgment task method is limited in the accuracy with which it predicts Task Definition behavior in real-world contexts.
- Factors that were not the focus of this research, namely age and level of education, may play a role in the categorization of information problems during Task Definition.

3.5 Revisiting Research Questions and Summary

This study was guided by the following overarching research question:

Overarching Research Question: What is the nature and impact of Task Definition in terms of information problem categorization within the information problem-solving process?

The following are the research questions related to this overarching question:

1. How do experts and novices in the domain of librarianship categorize domain-related information problems?

- 1.1. Specifically, how does the recognition and use of surface or deeper structural features in information problem categorization vary as a function of experience within the domain of librarianship?
- 1.2. How does the categorization by experts in the domain of librarianship compare to categorization by experts in other domains?

2. How do experts and novices in the domain of librarianship categorize information problems in domains other than librarianship?

2.1. Specifically, does expertise in the domain of librarianship result in the recognition and use of surface or deeper structural features in information problem categorization in near and far domains?

2.2. Why does the categorization by experts in the domain of librarianship transfer or fail to transfer to other domains?

Domain experts are better problem-solvers than novices because their knowledge is structured in ways that facilitate successful performance. In the initial stage of the problem-solving process, experts typically categorize problems based upon deeper structural features, whereas domain novices categorize problems based upon surface features. However, related studies were based upon well-structured tasks; for example, physics and mathematics problems. Library and information science is concerned with information problems, which by their nature are not well-structured. Therefore, the first phase of this study, corresponding to Research Question 1, was to investigate the categorization of information problems by experts and novices in the domain of librarianship. The methodology employs a triad judgment task in which participants will match one of two analog information problems to a target information problem. Experts will be compared to novices, and analysis of the data will determine preferences for deeper structural or surface features in their choices by domain experts and novices. Results will determine whether the focus on surface or deeper structural features varies as a function of experience within a domain. Moreover, results that may be expected based upon the results of the same methods used with well-structured problems may corroborate the appropriateness of these methods with ill-structured problems.

The information behaviors associated with information literacy parallel those of domain experts. The literature suggests, moreover, that information literate strategies are domain-general, and may be applied successfully across domains. The question of whether information literate behaviors constitute domain-general skills is the focus of Research Question 2. The methodology used to investigate this research question is the triad judgment task modified to investigate categorization in novel domains. Analysis of the data will determine preferences for deeper structural or surface features in categorization of information problems by domain experts as novices in a novel domain. As suggested by the literature, the information literacy skills associated with librarianship constitute domain-general procedural knowledge; it is hypothesized that expert librarians will choose deeper structural features in categorization of information problems, even in a novel domain.

4.0 Chapter 4: Results and Analysis

The analyses of data gathered in this study and the results from these analyses are presented in this chapter. First, an overview of the hypotheses formulated from the research questions and a rationale for the format of data analyses is presented in section 4.1. Then, responses to the Participant Description Survey are presented to provide a more complete picture of both expert and novice sample groups in section 4.2. The next section 4.3 presents results related to the categorization of experts and novices in the domain of librarianship, followed by the section 4.4 presenting results related to the categorization of experts and novices in other domains. Section 4.5 presents an exploratory analysis of the data with regard to age of participants. Section 4.6 presents an analysis of the data provided by participants during the Repertory Grid (RepGrid) Technique. Chapter 4 concludes with a summary of the results to be discussed in terms of the research questions in Chapter 5.

4.1 Introduction

As stated in Chapter 1, this study was designed to address gaps in our current understanding of information literacy, conceptualized in this research as information problem-solving expertise. Who are the experts? How do they think? Does this expertise transfer to novel problems and domains? This study seeks to identify expert information problem-solvers, and reveal their cognition during the initial stage of Task Definition. This study also seeks to determine if similar cognitive processes are applied to categorization of information problems across content domains. Taken together, these investigations aim to answer the overarching research question:

What is the nature and impact of Task Definition in terms of information problem categorization within the information problem-solving process?

The literature on the problem-solving success of domain experts reveals a distinct difference between them and novices. The organization of expert knowledge is different than that of novices within a domain; one of the ways this organization is different is that experts recognize the deeper structural features of problem situations, and will take this recognition into account in mentally representing and categorizing problems according to schema. In this way, experts make better judgments in the selection of solution strategies and are more successful at problem resolution than novices within their domain.

While the skills and stages associated with information literacy describe expertise in information problem-solving, scant research has been done to identify the experts in information problem-solving, and to reveal their cognition. Who are the information problem-solving experts? The first section of this chapter (4.2) describes the participants in this study who represent both experts in information problem-solving and novices. Demographic data of the participants in this

study is presented to build a more accurate profile of the information problem-solving expert than is currently available.

The next section (4.3) initiates the process of comparing the two groups. In this section, results related to the categorization of experts and novices in the domain of librarianship are presented. This study first seeks to determine if training and experience in librarianship results in expert thinking in information problem-solving. Do information problem-solving experts recognize the deeper structural features of problem situations within their domain, and make categorical determinations accordingly? It is expected that these experts will engage cognition in ways similar to experts in a variety of other domains. The first research sub-question addresses these issues:

1. How do experts and novices in the domain of librarianship categorize domain-related information problems?

The corresponding hypothesis tested in this study (H1) is that experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition. Data collected from the online triad judgment tasks related to librarianship was analyzed quantitatively and results are presented in this section.

- (H1) Experts in information problem-solving categorize information problems within their domain based upon deeper structural features versus surface features during Task Definition.

The following section (4.4) presents the results related to the categorization of experts and novices in the new and unfamiliar domains of everyday life information and statistics. Another gap identified by a reading of the literature is the transfer of information problem-solving skills.

Definitions and descriptions of information literacy imply that these skills may be applied to a variety of problem situations within a variety of domains. But, do information problem-solving experts recognize the deeper structural features of problem situations in other domains, and continue to make categorical determinations accordingly? Again, there is scant research to support these implications. This study seeks to begin exploring this proposition. The second research sub-question addresses this issue:

2. How do experts and novices in the domain of librarianship categorize information problems in domains other than librarianship?

The corresponding hypothesis tested in this study (H3) is that experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in new or unfamiliar domains. Data collected from the online triad judgment tasks related to everyday life information and statistics was analyzed quantitatively and results are presented in this section.

- (H3) Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.

The design of this research focused on the independent variables of expertise, comparison type, and domain type. However, other factors may have effects on the dependent variable of performance in categorical determinations. Section 4.5 takes an exploratory approach to analyzing the data collected to determine the effect of age.

Section 4.6 presents a qualitative analysis of the data collected from the sorting task employing the RepGrid Technique. This analysis provides insight into the rationale expert, novice, and

exploratory sample group participants used to make categorical determinations, and serves to create a more complete picture of information problem-solving expertise. It also enables testing of the hypotheses generated from each of the research sub-questions:

- (H2) The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.
- (H4) The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains.

To review, this chapter presents the results of this research as follows:

- A Profile of Study Participants (section 4.2)
- Categorization of Experts and Novices in the Domain of Librarianship (section 4.3)
- Categorization of Experts and Novices in Other Domains (section 4.4)
- An Exploratory Analysis of the Effect of Age on Categorical Determinations (section 4.5)
- Rationale for Categorical Determinations Made by Experts and Novices (section 4.6)
- Summary of Results (section 4.7)

4.2 A Profile of Study Participants

It is useful to begin an analysis of the data with a description of the experts and novices who participated in this study before proceeding to comparisons between the two groups. This information contributes to a more accurate profile of the typical expert in information problem-solving than is currently available.

This section describes efforts to recruit participants for assignment to either the expert or novice group, and provides demographic information.

4.2.1 Results of Recruitment Efforts

According to the procedures described in section 3.3.3, 208 participants completed all of the online judgment tasks and the Participant Description Survey. The Catalyst WebQ tool was set to require that a participant respond to each triad judgment task or Participant Description Survey question before moving on to the next; moreover, the tool only recorded a complete set of responses. Therefore, it is impossible to know how many participants only partially completed the online triad judgment tasks. The online triad judgment task instrument was open for participant recruitment continuously from August 3, 2015 until May 14, 2016.

4.2.2 Demographics

Participants were recruited for each sample group employing different methods. However, the researcher expected the overall participant group to be gender-balanced and typically English-language fluent. In fact, while 96.6% of participants reported themselves to be English language fluent, 69.7% reported themselves to be female, contradicting the expectation of gender balance.

The researcher did expect that recruitment method differences would result in significant differences in education level and age. Of the 78 participants recruited for the novice group, 65 reported a high school or equivalent level of education, and 13 reported having earned bachelor's degree. Of the 130 participants recruited for the expert group, 127 reported having earned a master's degree, and 3 reported having earned a doctorate degree. The age of these participants trends toward the 18-25 years old range (34.1%), clearly given the convenience sampling of students enrolled in undergraduate courses; by contrast, the second-largest age group is the 56 or

more years old range group (20.7%). The remaining distribution is rather even: 12.0% for the 26-35 years old range, 17.8% for the 36-45 years old range, and 15.4% for the 46-55 years old range.

		Gender		
		Frequency	Percent	Cumulative Percent
Valid	Female	145	69.7	69.7
	Male	63	30.3	100.0
	Total	208	100.0	

Table 4.2.2A: Participant Gender

		English Language Fluency		
		Frequency	Percent	Cumulative Percent
Valid	Fluent in English	201	96.6	96.6
	Developing Fluency in English	7	3.4	100.0
	Total	208	100.0	

Table 4.2.2B: Participant English Language Fluency

		Education Level		
		Frequency	Percent	Cumulative Percent
Valid	High School or Equivalent	65	31.3	31.3
	Bachelor's Degree	13	6.3	37.5
	Master's Degree	127	61.1	98.6
	PhD	3	1.4	100.0
	Total	208	100.0	

Table 4.2.2C: Participant Education Level

		Age		
		Frequency	Percent	Cumulative Percent
Valid	18-25 years old	71	34.1	34.1
	26-35 years old	25	12.0	46.2
	36-45 years old	37	17.8	63.9
	46-55 years old	32	15.4	79.3
	56 or more years old	43	20.7	100.0
	Total	208	100.0	

Table 4.2.2D: Participant Age

4.2.3 Domain Experience

In the Participant Survey, participants were asked to report their experience in the field of librarianship. To account for those who may have worked in library service in some informal capacity, the following options were presented:

1. No experience: I have never taken a course related to librarianship, nor have I worked in the field
2. Some experience: I have taken one or more courses related to librarianship, or I have worked in the field
3. Experienced: I have completed a graduate degree in library and information science (or equivalent), and I have worked in the field for less than 10 years
4. Very Experienced: I have completed a graduate degree in library and information science (or equivalent), and I have worked in the field for 10 years or more

According to the rationale described in section 3.3.3, only participants who completed a graduate degree in library and information science (options 3 and 4) qualified as an expert. Therefore, all participants who selected option 1 (n=59) or option 2 (n=19) were included in the novice sample group (n=78). Participants who selected options 3 or 4 (n=130) were then asked to select a library experience setting; those selecting options 1 or 2 skipped to the next question. In the total of all participants, the most frequently-reported setting was an academic library setting (32.2%), followed by a public library setting (24.5%), and a school library setting (4.8%). Two participants (1.0%) reported experience in a different library setting: “PK-5 elementary and College level” and “K-12 school library and academic library.” No participants reported experience in a corporate library setting. The novice group with no experience in a library setting represents the remaining balance of the total group (37.5%).

The cross-tabulation of age with librarianship experience reveals some unexpected results. Of the 78 participants in the novice group, reporting no or some librarianship experience, 71 (91.0%) are in the 18-25 years old range and the remaining 7 are in the over 25 years old ranges; it cannot be assumed that all students enrolled in undergraduate courses are under 26 years old. Of the 130 participants in the expert group, reporting completion of a graduate degree in library and information science or beyond, they are rather evenly distributed among the over 25 years old age ranges: 24 in the 26-35 years old age range (18.5%), 33 in the 36-45 years old age range (25.4%), 31 in the 46-55 years old age range (23.8%), and 42 in the 56 or more years old age range (32.3%). It was expected that none of the expert participants would be in the 18-25 years old age range, since those who complete a graduate degree are typically over 25 years old.

The research was designed to include triad judgment tasks with information problems from a domain that was likely to be unfamiliar to participants. The researcher selected the domain of statistics, and used information problem scenarios from an earlier study (Quilici & Mayer, 1996), with permission from the authors. To confirm that this was indeed an unfamiliar domain, participants were asked to report their experience within the field of statistics:

1. No experience: I have never taken a course related to statistics, nor have I worked in the field
2. Some experience: I have taken one or more courses related to statistics, or I have worked in the field
3. Experienced: I have earned a graduate degree in statistics, and I have worked in the field for less than 10 years
4. Very Experienced: I have earned a graduate degree in statistics, and I have worked in the field for 10 years or more

No participants reported themselves as being experienced or very experienced (options 3 and 4). Of the total sample, some reported themselves as having some experience (n=129, 62.0%), and the remainder reported no experience at all (n=79, 38.0%). These results are acceptable to the researcher, as none of the participants could be characterized as experts in the domain of statistics (for example, if they had completed a graduate degree in statistics, or worked in the field for more than 10 years). When cross-tabulated with librarianship experience, the proportions of participants reporting some experience in statistics are similar (n=52, 66.7% for novices; n=77, 59.2% for experts). Based on these results, it is expected that all participants will be unfamiliar with the information problems in the statistics domain, and make categorical determinations as would be expected of novices.

		Librarianship Experience		
		Frequency	Percent	Cumulative Percent
Valid	Novice	78	37.5	37.5
	Expert	130	62.5	100.0
	Total	208	100.0	

Table 4.2.3A: Participant Expertise in the Domain of Librarianship

		Library Experience Setting		
		Frequency	Percent	Cumulative Percent
Valid	No Experience in a Library Setting	78	37.5	37.5
	Public Library Setting	51	24.5	62.0
	K-12 School Library Setting	10	4.8	66.8
	Academic Library Setting	67	32.2	99.0
	Other Library Setting	2	1.0	100.0
	Total	208	100.0	

Table 4.2.3B: Setting of Participant Library Experience

Age * Librarianship Experience Cross-tabulation

		Librarianship Expertise		Total	
		Novice	Expert		
Age	18-25 years old	Count	71	0	71
		% within Librarianship Expertise	91.0%	0.0%	34.1%
	26-35 years old	Count	1	24	25
		% within Librarianship Expertise	1.3%	18.5%	12.0%
	36-45 years old	Count	4	33	37
		% within Librarianship Expertise	5.1%	25.4%	17.8%
	46-55 years old	Count	1	31	32
		% within Librarianship Expertise	1.3%	23.8%	15.4%
	56 or more years old	Count	1	42	43
		% within Librarianship Expertise	1.3%	32.3%	20.7%
Total		Count	78	130	208
		% within Librarianship Expertise	100.0%	100.0%	100.0%

Table 4.2.3C: Comparison of Participant Age and Librarianship Experience

Statistics Experience

		Frequency	Percent	Cumulative Percent
Valid	No Statistics Experience	79	38.0	38.0
	Some Statistics Experience	129	62.0	100.0
Total		208	100.0	

Table 4.2.3D: Participant Experience in the Domain of Statistics

Statistics Experience * Librarianship Experience Cross-tabulation

		Librarianship Expertise		Total	
		Novice	Expert		
Statistics Experience	No Statistics Experience	Count	26	53	79
		% within Librarianship Expertise	33.3%	40.8%	38.0%
	Some Statistics Experience	Count	52	77	129
		% within Librarianship Expertise	66.7%	59.2%	62.0%
Total		Count	78	130	208
		% within Librarianship Expertise	100.0%	100.0%	100.0%

Table 4.2.3E: Comparison of Participant Statistics and Librarianship Experience

4.2.4 Information Literacy Description

Participants were also asked to evaluate their own information literacy. It was expected that participants in the expert sample group would rate themselves highly, and those in the novice sample group would not. Participants overall rated themselves rather highly, with only 7.2% selecting the “not information literate” option, and 18.3% selecting the “somewhat information literate” option. A full 74.5% of all participants from both groups rated themselves as “reasonably information literate” (41.8%) or “very information literate” (32.7%). As explained by Gross (2005, 2007; 2009) and others, there is little correlation between self-assessment of information literacy skills and actual information literacy skills.

While these results are not the focus of this study, they are notable. As expected, given their training and experience in the field of library and information science, nearly all participants in the expert sample group (97.7%) rate themselves as “reasonably” (48.5%) or “very information literate” (49.2%). What was not expected is the number of participants from the novice sample group who rated themselves as “reasonably” (30.8%) or “very information literate” (5.1%). In other words, 35.9% of participants in the novice sample group feel they are reasonably or very information literate with no training or experience to support this view of their skills.

There are likely to be few surprises in a cross-tabulation of information literacy self-evaluation and age, given the methods of recruitment for expert and novice sample groups, but some interesting results do occur. For example, for those rating themselves as “reasonably” or “very information literate,” the frequencies in each of the age ranges appears to be rather evenly distributed. In other words, many participants have a high regard for their information literacy

skills regardless of age or experience. In the cross-tabulation of information literacy and education level, it appears that those with a master’s or doctorate level of education (in library and information science, of course) view themselves as “reasonably” or “very information literate.” However, there is a higher-than-expected number of participants with confidence in their skills who report high school or bachelor’s degree levels of education. Of those reporting a high school or equivalent level of education, only 21.5% report themselves as “not information literate” and nearly one-third (29.2%) report themselves as “reasonably” or “very information literate.” Similarly, of those reporting a bachelor’s degree level of education, more than two-thirds (69.2%) report themselves as “reasonably” or “very information literate.” These results seem to corroborate the findings of Gross and others.

Information Literacy Self-Evaluation

		Frequency	Percent	Cumulative Percent
Valid	Not Information Literate	15	7.2	7.2
	Somewhat Information Literate	38	18.3	25.5
	Reasonably Information Literate	87	41.8	67.3
	Very Information Literate	68	32.7	100.0
	Total	208	100.0	

Table 4.2.4A: Participant Self-Evaluation of Information Literacy

Information Literacy Self-Evaluation * Librarianship Experience Cross-tabulation

		Librarianship Expertise		Total	
		Novice	Expert		
Information Literacy Self-Evaluation	Not Information Literate	Count	15	0	15
		% within Librarianship Expertise	19.2%	0.0%	7.2%
	Somewhat Information Literate	Count	35	3	38
		% within Librarianship Expertise	44.9%	2.3%	18.3%
	Count		24	63	87

	Reasonably Information Literate	% within Librarianship Expertise	30.8%	48.5%	41.8%
	Very Information Literate	Count	4	64	68
		% within Librarianship Expertise	5.1%	49.2%	32.7%
Total		Count	78	130	208
		% within Librarianship Expertise	100.0%	100.0%	100.0%

Table 4.2.4B: Comparison of Participant Information Literacy and Librarianship

Experience

Information Literacy Self-Evaluation * Age Cross-tabulation

			Age					
			18-25	26-35	36-45	46-55	56 or more	Total
			years old	years old	years old	years old	years old	
Information Literacy Self-Evaluation	Not Information Literate	Count	15	0	0	0	0	15
		% within Age	21.1%	0.0%	0.0%	0.0%	0.0%	7.2%
	Somewhat Information Literate	Count	35	0	2	1	0	38
		% within Age	49.3%	0.0%	5.4%	3.1%	0.0%	18.3%
	Reasonably Information Literate	Count	18	15	14	16	24	87
		% within Age	25.4%	60.0%	37.8%	50.0%	55.8%	41.8%
	Very Information Literate	Count	3	10	21	15	19	68
		% within Age	4.2%	40.0%	56.8%	46.9%	44.2%	32.7%
	Total	Count	71	25	37	32	43	208
		% within Age	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4.2.4C: Comparison of Participant Information Literacy and Age

Information Literacy Self-Evaluation * Education Cross-tabulation

		Education				Total	
		High School or Equivalent	Bachelor's Degree	Master's Degree	PhD		
Information Literacy Self- Evaluation	Not Information	Count	14	1	0	0	15
	Literate	% within	21.5%	7.7%	0.0%	0.0%	7.2%
		Education					
	Somewhat	Count	32	3	3	0	38
		% within	49.2%	23.1%	2.4%	0.0%	18.3%
	Literate	Education					
		Count	18	7	62	0	87
	Reasonably	% within	27.7%	53.8%	48.8%	0.0%	41.8%
		Education					
	Very Information	Count	1	2	62	3	68
% within		1.5%	15.4%	48.8%	100.0%	32.7%	
Literate	Education						
	Count	65	13	127	3	208	
Total	% within	100.0%	100.0%	100.0%	100.0%	100.0%	
	Education						

Table 4.2.4C: Comparison of Participant Information Literacy and Education

4.2.5 Additional Descriptions

Of the 208 participants in this study, 87 indicated a willingness to participate in the follow-up study, Phase 2. Of those, 15 participated (10 in the expert sample group, and 5 in the novice sample group—5 more were included in the novice group, but were recruited via a snowball sampling technique). Ten more were recruited to form the exploratory group; a convenience sampling technique was employed in this recruitment. Of the 208 participants in this study, 186 indicated an interest in participation in a random drawing for a gift certificate.

4.3 Categorization of Experts and Novices in the Domain of Librarianship

The preceding section highlighted demographic similarities and differences between the expert and novice sample groups. The next step is to compare performance differences.

In this section, the following hypothesis will be examined:

- (H1) Experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition.

Do domain experts rely on deep structural features of problem scenarios to categorize problems compared to novices across comparison types? The null hypothesis to be tested is that there is no significant difference between the experts and novices in the domain of librarianship in the selection of analog scenarios with deeper structural feature similarities to a target scenario. This hypothesis is tested first in this section.

Do experts always make categorical determinations based on deeper structural feature similarity when it is present? Do novices always make categorical determinations based on surface feature similarity when it is present? These related questions are examined later in the section.

4.3.1 Preliminary Analysis of S-D + N-D Comparison Types

In this study, experts in information problem-solving are operationalized as trained and experienced librarians in practice; novices are participants with little to no training nor experience in librarianship. Participants were assigned to groups as described in the previous section. The categorization of analog scenarios based on surface or deeper structural feature similarities was examined under three different conditions in the set of scenarios related to the domain of librarianship, S-D, N-D, and S-N. In the S-D comparison type, one analog scenario is similar to the target scenario only in surface features (S) and the other is similar only in deeper structural features (D). In the N-D comparison type, one analog scenario is not similar to the target scenario in either aspect (N), and the other is similar only in deeper structural features (D). The first comparison type, S-D, allowed for a straightforward comparison between groups:

would experts select the D option, and the novices select the S option in this comparison type at a significant level? The second comparison type, N-D, allowed for a comparison without the distraction of surface feature similarity: would the differences in selection be more pronounced, or would novices look for deeper structural feature similarities in the absence of any surface feature similarity?

The third comparison type, S-N, where one analog scenario is similar to the target scenario only in surface features (S) and the other is not similar in either aspect (N), was not included in this first null hypothesis test, since there was not an option that included a deeper structural feature similarity. That comparison served to prevent test priming, and is examined later in a test for novice preference for surface feature similarity in categorical determinations.

Scores were calculated for the “best” selection in each of the D comparison types, S-D and N-D. The “best” selection is the analog scenario with the deeper structural feature similarity (D). Participants received a score for each comparison type within the set of triad judgment tasks related to the domain of librarianship; participants could receive a score of up to 6 in each.

In the first comparison type (S-D), an analog scenario with only a surface feature similarity with the target scenario appears along with an analog scenario with only a deeper structural feature similarity with the target scenario. Based on research on expert thinking, it was expected that experts would select the analog with the deeper structural feature similarity 100% of the time; since there were six of this type of comparison, it was expected that experts would receive a score of 6 for this comparison type. It was expected that novices would select the analog with the surface feature similarity 100% of the time; it was expected that they would receive a score of 0 for this comparison type.

In the second comparison type (N-D), an analog scenario with no similarity with the target scenario appears along with an analog scenario with only a deeper structural feature similarity with the target scenario. Based on research on expert thinking, it was expected that experts would select the analog with the deeper structural feature similarity 100% of the time; since there were six of this type of comparison, it was expected that experts would receive a score of 6 for this comparison type. Without a surface feature similarity in either case, it was expected that novices would select either analog scenario in equal measure; thus, it was expected that they would receive a score of 3 for this comparison type.

Table 4.3A shows the comparison of predicted and observed selection of analog scenarios with deeper structural similarity for each comparison type, and the totals for both comparison types added together. Cumulative participant score percentages compared to predicted scores reveal that expert performance was lower than predicted (68% versus 100%), and novice performance was higher than expected (54% versus 25%).

It is informative to look more closely at participant performance, however, by examining performance under each condition of comparison type. For the S-D comparison, the percentage of D-analog selections made by the expert group is lower than expected at 58%. The percentage of D-analog sections made by the novice group is higher than expected at 41%. That is, while novices selected the analog scenario with the deeper structural similarity only 41% of the time, it was expected that they would never select this analog.

For the N-D comparison which eliminates the distraction of an analog with similar surface features, once again the expert group selected the D analog less frequently than expected, and the novice group selected the D analog more frequently than expected. Although outcomes in both

comparison types are closer than expected, the expert group did meet expectations by selecting D analogs more frequently than those in the novice group. The means calculated for each comparison type in Table 4.3B corroborate this pattern. The next step is to determine if group differences are significant.

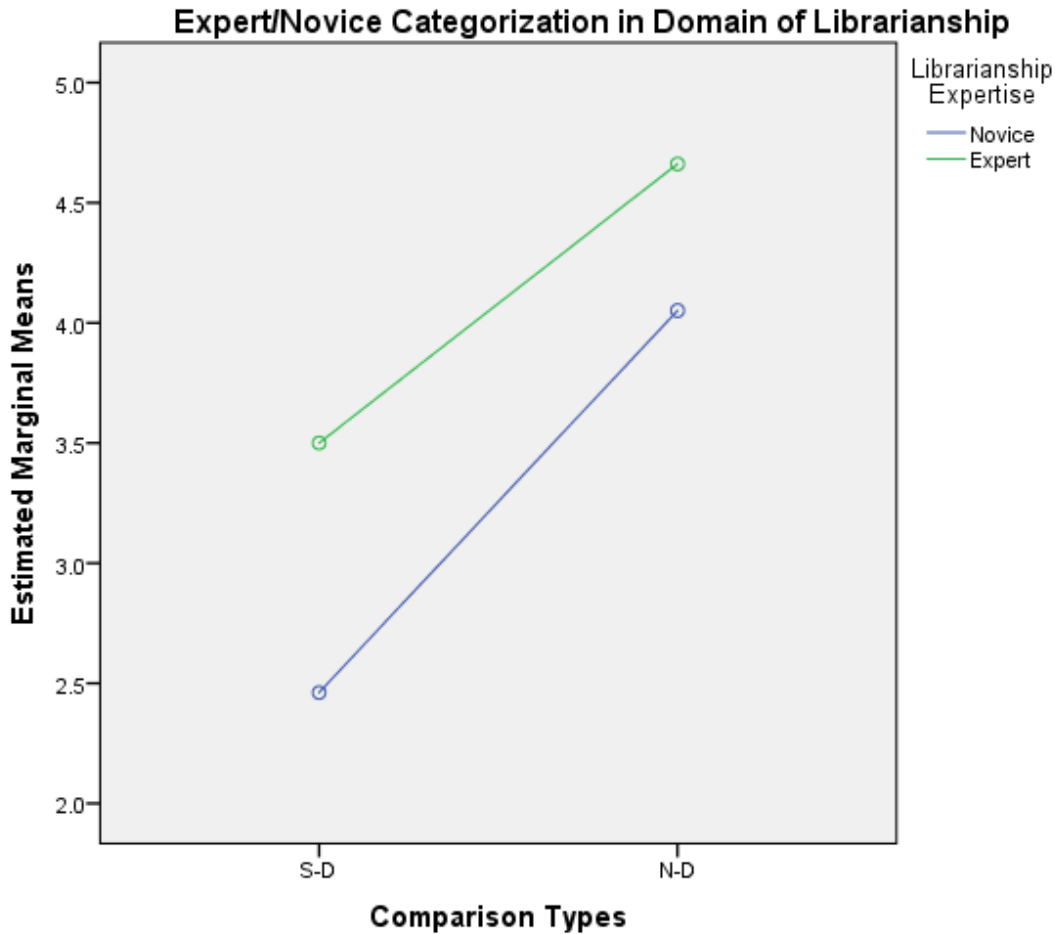
Comparison Type (Domain: Librarianship)	Librarianship Expertise			
	Experts		Novices	
	Predicted % D	Observed % D	Predicted % D	Observed % D
S-D	100	58	0	41
N-D	100	78	50	68
Total		68		54

Table 4.3.1A: Predicted and Observed Scores

	Librarianship Expertise	Mean	Std. Deviation	N
Score S-D Lib	Novice	2.46	1.718	78
	Expert	3.50	1.556	130
	Total	3.11	1.692	208
Score N-D Lib	Novice	4.05	1.268	78
	Expert	4.66	1.038	130
	Total	4.43	1.165	208

Table 4.3.1B: Descriptive Statistics for Comparison Types

When the means are plotted on a scale comparing group means for each comparison type, an interesting picture emerges. While the means for the expert group are higher than those for the novice group for both comparison types, the gain in mean is greater in the second comparison type when the distraction of the S analog is removed. The plot lines do not intersect, but they are not parallel either, indicating that there may be a small interaction effect of expertise and comparison type.



4.3.2 Statistical Analysis of S-D + N-D Comparison Types

The data is interval scale, so a 2x2 factor split-plot (sometimes referred to as “mixed-design”) analysis of variance (ANOVA) was calculated to test the null hypothesis, that there is no significant difference in means between the experts and novices in the domain of librarianship in the selection of analog scenarios with deeper structural feature similarities in either comparison type. Factor A is expertise with two levels: expert or novice; it is a between-subjects measure. Factor B is comparison type, S-D and N-D; this is the repeated measures, within-subjects factor. The dependent variable is the performance score in each of the three domains; participants were given a point for each selection of the D analog, that is, the analog scenario that matched the

target scenario in deeper structural features. There were six triad judgment tasks in each comparison type, so a total score of 6 was possible.

First, some of the assumptions made in the following statistical analysis were tested. Levene's Test of Equality of Error Variances yielded a non-significant result ($F(1,206) = 2.59, p (.109) > .05$; $F(1, 206) = 3.60, p (.059) > .05$), meaning that the assumption of homogeneity of variance was not violated. Since Box's M (4.51) was not significant either, $p (.624) > \alpha (.001)$, there are no significant differences between the covariance matrices, and the required assumptions for the ANOVA have not been violated.

The Effect of Comparison Type

The test found a significant main effect of comparison type, $F(1, 206) = 150.68, p < .05, \eta^2 = .422$. The η^2 multivariate result indicates that approximately 42% of multivariate variance of the dependent variable is associated with comparison type, a large effect size (J. Cohen, 1988). This indicates that taken together, both groups scored differently in a significant way from one comparison type to the next; in other words, if we ignore whether the score came from an expert or a novice, the scores in each comparison type differed significantly. Although the plot suggested that this was the case, the result is surprising since it was expected that experts would select the D analog regardless of comparison type. It remains unclear from this analysis whether this significant difference was due to a change in expert performance from one condition to the next, or if the change in novice performance, which was expected, was large enough to affect this result.

The Effect of Librarianship Expertise

Also significant is the main effect of expertise, $F(1, 206) = 24.79, p < .05, \eta^2 = .107$. The partial eta multivariate result indicate that approximately 11% of multivariate variance of the dependent variable is associated with expertise, a medium-to-large effect size (Cohen, 1988). This indicates that combined scores for all comparison types are significantly different for experts and novices; in other words, if we ignore the type of comparison, experts and novices scored differently in a significant way. Again, the plot suggested that this would be the case, so this result is not surprising since it was expected that there would be a significant difference in performance between experts and novices, regardless of comparison type condition.

The Interaction Effect of Comparison Type x Expertise

However, the interaction of the main effects was non-significant, $F(1, 206) = 3.65, p = .057, \eta^2 = .017$. In other words, the magnitude of either main effect is not related to the other; this indicates that scores in the two comparison types did not differ in experts and novices. However, the p-value of .057 is close to the .05 threshold for rejecting the null hypothesis that there is no significant difference between the two groups in the selection of the D analog scenario. Novice selection of the D analog improved more dramatically from S-D to N-D comparison types than expert selection. These results may indicate that the presence of surface feature similarities may play a far greater role in categorical determinations than was predicted.

The relevant hypothesis, based on the first key research question, states:

- (H1) Experts in information problem-solving categorize information problems based upon deeper structural features versus surface features during Task Definition.

The preceding results are based on a comparison of the performance of experts in the domain of librarianship to the performance of novices in two different comparison types. Test results

indicate that the difference is indeed significant for the main effects of expertise and comparison type. The null hypothesis, that there is no significant difference in means between the experts and novices in the domain of librarianship in the selection of analog scenarios with deeper structural feature similarities to a target scenario, may be rejected.

These results are consistent with the preliminary analysis indicating that there are significant differences in the categorical determinations made by experts and novices in the domain of librarianship in each comparison type, and that there are significant differences in these determinations between comparison type. However, there is no evidence to support an interaction effect, that expertise will have an impact on categorical determination differences between groups across comparison types. Had experts based their categorical determination solely on deeper structural similarity, then there would have been no difference between comparison types for that group. Yet, the presence of surface feature similarity alters these determinations for both experts and novices.

4.3.3 Statistical Analysis of S-D + N-D Comparison Types: Another Perspective

This analysis was performed to test the effects of a between-subjects variable, expertise, in combination with a within-subjects variable, comparison type. This enabled an examination of each of the main effects, and the interaction of those effects.

There is another way to look at this data to test the initial hypothesis. Rather than compare scores from the expert group with scores from the novice group, it may be useful to compare scores against random selection of analog scenario. In other words, instead of comparing expert scores on the S-D comparison type to novice scores on the S-D comparison type, expert scores on the S-D comparison type may be compared to the expected score of a participant selecting an S or D

analog scenario completely at random. In this case, it would be expected that each expert would score a 6, and that someone selecting at random would score a 3. This analysis will enable focus on expert categorical determinations, and provide an answer to the following question:

- Do **experts** rely on **deep structural features** of problem scenarios to categorize problems within expertise domain?

Hypothesis 1: Triad Comparison S-D

The researcher's hypothesis for Triad Comparison 1 is that experts will choose the analog problem that matches the target task problem in deeper structural features. According to the triad judgment task method employed by Hogan & Rabinowitz (2009), choices made by participants are scored. For Triad Comparison 1, a score of 1 will be assigned when the participant chooses the analog task problem with the matching deeper structural features (D-analog), and 0 for the analog task problem with the matching surface features (S-analog). According to the hypothesis, experts should receive a total score of 6.0, and novices should receive a total score of 0.0. Actual scores will then be compared to a mean value of 3.0, which is the expected value for participants choosing at random.

Hypothesis 2: Triad Comparison N-D

For Triad Comparison 3, the researcher's hypothesis is that experts will choose the analog problem with matching deeper features; novices will choose either analog task problem at random. Therefore, expert choice of the D-analog will receive a score of 1, and a score of 0 will be assigned to the choice of the analog problem with no matching features (N-analog). According to the hypothesis, experts will score 6.0, and novices will score 3.0; actual scores will be compared to the value of 3.0.

Hypothesis Testing

To employ this approach, a series of t-tests were performed, with a Bonferroni correction applied to each (Table 4.3C). For these four planned comparisons, a significance level of $p < .0125$ was applied to maintain the experiment-wide Type I Error level at $p < .05$. The null hypothesis in test 1 is that experts do not make categorical determinations for information problem scenarios based on deeper structural feature similarities under the S-D comparison type condition. The results were significant for this test condition, $t(129) = 3.66, p < .0125$; therefore, the null hypothesis may be rejected. The null hypothesis may also be rejected for the second test condition, test, 2, when the comparison type is N-D, $t(129) = 18.24, p < .0125$. In both cases, the observed means are greater than that of random selection, suggesting that experts do indeed make categorical determinations based on deeper structural features for information problem scenarios within their domain, regardless of comparison type. While both results are significant, the mean for the N-D condition (4.66), in which there is no analog with a surface feature similarity, is greater than the mean for the S-D condition (3.50), suggesting that surface feature similarity does interfere with categorical determinations.

Analysis of novice performance under these conditions reveals a different picture. In these tests, the null hypothesis is that novices do not make categorical determinations for information problem scenarios based on deeper structural feature similarities under each comparison type condition. The results were significant for both the S-D condition ($t(77) = 12.65, p < .0125$) and the N-D condition ($t(77) = 28.22, p < .0125$). Therefore, the null hypothesis may be rejected for each of these test conditions. In the second condition where there is no S-analog, the observed mean is 4.05; novices perform more like experts in this condition. The first condition result is more complex. The observed mean for the novice S-D condition (2.46) is less than the random

selection mean of 3.00; this suggests that in this condition, novices are making categorical determinations based on something that is not deeper structural feature similarity. These tests do not address factors other than deeper structural feature similarity selection. The next section presents an analysis of categorical determinations based on surface features.

Librarianship Expertise	Comparison Type	Random Selection Mean	Observed Mean	Observed Std. Deviation	t	p value
Expert (n=130)	S-D	3.00	3.50	1.556	3.663	< .0125
	N-D	3.00	4.66	1.038	18.243	< .0125
Novice (n=78)	S-D	3.00	2.46	1.718	12.651	< .0125
	N-D	3.00	4.05	1.268	28.218	< .0125

Table 4.3.1C: Comparison of Expert and Novice Scores to Expected Scores

4.3.4 A Focus on Domain Novices: Analysis of S-N + S-D Comparison Types

This research is an examination of expert information problem-solving behavior. Specifically, it focuses on the categorical determinations of experts during Task Definition. However, it is informative to concurrently examine the assumptions made about novice behavior, that domain novices will make categorical determinations based on surface features of problem situations.

The research design included three types of triad judgment comparison to look at categorical determinations of experts from three perspectives. The first is a choice of an analog scenario with either a surface feature similarity to the target scenario (S-D); this allows for an examination of whether experts will categorize according to deeper structural feature similarity, even with the distraction of an analog with a surface feature similarity. The second offers a choice of either an analog scenario with a deeper structural feature similarity or one with no similarity at all; this comparison type allows for a clear choice without distraction. With regard to examining expert categorical determination, the third comparison type served as a control type; since there was no

option with a deeper structural feature similarity, these triads were placed strategically to prevent test priming.

However, this comparison type also allows for an examination of the assumption that novices will make categorical determinations based on surface feature similarity in a significant way. Put another way:

- Do **novices** rely on **surface features** of information problem scenarios to categorize problems within an unfamiliar domain?

Data collected for the two related comparison types, S-D and S-N, will be useful in this analysis. However, this time the analog scenario with the surface feature similarity with the target scenario, S, will be the “best” selection, and scores are calculated accordingly. Table 4.3.2A shows predicted and observed scores on the two comparison types with an S analog. Note that the novice group is the focus in this analysis, but scores for the expert group based on S analog selections have also been calculated for comparison.

Comparison Type (Domain: Librarianship)	Librarianship Expertise			
	Novices		Experts	
	Predicted % S	Observed % S	Predicted % S	Observed % S
S-D	100	59	0	42
S-N	100	79	50	80
Total	100	69	25	61

Table 4.3.4A: Predicted and Observed Scores for S Comparison Types

Based on a review of the literature, it was expected that domain novices would always select the analog scenario with surface feature similarity to the target (S), regardless of comparison type. However, this was not the case. While the novice group did indeed select the S analog in the case where there was no analog with a deeper structural feature similarity (S-N) most of the time

(79%), when presented with a D analog, novices selected the S analog much less frequently (59%), suggesting that novices do consider deeper structural feature similarity when making categorical determinations.

Comparing these frequencies to expert performance when focusing on S analog selection, experts also made categorical determinations based on surface feature similarity in the absence of a D analog option (in the S-N comparison type). The frequencies for S analog selection under this comparison type for novices and experts are 79% and 80%. Under the S-D comparison type, experts selected the S analog 42% of the time, which is much higher than expected. However, it parallels the difference between comparison types of novices, suggesting that the presence of surface feature similarity in an analog scenario makes categorical determinations complex. The next step is to complete a statistical analysis of the novice categorical determinations based on surface feature analog similarity.

Statistical Analysis of S-D + S-N Comparison Types

Again, this strand of analysis is focused squarely on testing the assumption of novice categorical determination based on surface feature similarity. Therefore, a t-test has been applied to novice performance scores in each of the two comparison types that include an S analog, S-D and S-N. These performance scores were compared to the score of a participant selecting analog scenarios at random to determine if novices in this group do select S analogs in a significant way. A Bonferroni correction was applied to each comparison. For these two planned comparisons, a significance level of $p < .025$ was applied to maintain the experiment-wide Type I Error level at $p < .05$. The null hypothesis in the first test is that novices do not make categorical determinations for information problem scenarios based on surface feature similarities under the

S-D comparison type condition. The results were significant for this test condition, $t(77) = 2.767$, $p = .007$; therefore, the null hypothesis may be rejected. The mean distribution of this sample group of domain novices is different than that of a population that is selecting analog scenarios at random.

The null hypothesis may also be rejected for the second test condition, when the comparison type is S-N, $t(77) = 11.353$, $p < .025$. Under both conditions S-D and S-N, the mean distribution of the sample group of domain novices is different than that of a population that is selecting analog scenarios at random. These results suggest that novices in the domain of librarianship tend to make categorical determinations of information problems based on surface feature similarities. However, comparing the performance mean for S analog selection in the S-D comparison type (3.54) with the performance mean in the S-N comparison type (4.77) suggests that novices will make these determinations less frequently when an option with deeper structural feature similarity is offered.

Comparison Type	Random Selection Mean	Observed Mean	Observed Std. Deviation	df	t	p value
S-D	3.00	3.54	1.718	77	2.767	.007
S-N	3.00	4.77	1.376	77	11.353	.000

Table 4.3.4B: Comparison of Novice S Analog Scores to Expected Scores

4.3.5 Exploratory Case Analyses: Comparison Types

Who were the top scorers? Who were the bottom scorers?

It will be useful to take a closer look at performance extremes: those experts who scored a perfect 12 on those triad judgment tasks that included a D-analog, and those that scored a zero. Similarly, it will be useful to compare these groups with corresponding groups from the novice

sample. While it was expected that the top scorers would be represented by participants in the expert group, this was not necessarily the case. Similarly, the participants with the lowest scores were not all from the novice group.

In order to make equivalent comparisons, participants from each group that performed the same at the top and at the bottom were compared. Comparing the top 10 scorers at each end may yield wildly different scores and likely render any comparison meaningless. Therefore, by manipulating the criterion for qualification as a “high scorer” (11-12 out of 12 total possible points) and as a “low scorer” (0-3 out of 12 possible points), it is possible to create two groups that are nearly equal in size for comparison (n=18 for the high scoring group and n=17 for the low scoring group). Many factors could contribute to the outcomes presented in this section, as they represent participant outliers. Therefore, this analysis is exploratory.

The following observations are apparent from a comparison of high (Table 4.3.5A) and low scorers (Table 4.3.5B) from each sample group:

- More experts in the top scoring group (77.8%), and more novices in the low scoring group (64.7%).
- The only participant to select all D-analogs in both S-D and N-D comparison type triad judgment tasks reported a bachelor’s degree level of education; since this participant was included in the expert group, either the participant misreported the education level, or is working in a library setting in a role other than as reference librarian.
- Similarly, one of the top scorers in the novice group reported a master’s degree education level and an age range of 36-45 years old; this is not typical of the sample group.

- Of the 18 top scorers in both groups, 72.2% were female, which is similar to the 69.7% proportion of female to males in the total sample group; whereas, in the low scoring group, only 47.1% were female.
- The lowest-scoring participants in the novice group, those scoring 1 or 2 out of 12, are all males (n=5). An explanation is difficult to formulate for this result; if these participants were simply selecting analogs randomly to expedite the completion of the tasks, they would have scored higher just by chance. Moreover, since the total score for these participants reflects a failure to select the D-analog not only when an S-analog was available, but also when an N-analog was available, it seems that they were executing some type of strategy that resulted in selection of anything but a D-analog!
- All participants in these groups reported fluency in English; 3.4% of all participants reported developing fluency in English, but none of these turned up in either the high or low scoring groups.
- Of the expert participants in both high and low scoring groups, library setting experience was representative of the entire sample: academic (50.0%), public (40.0%), and K-12 school (10.0%).
- Within the top scoring group, the experts all self-evaluated their information literacy skills at the top end as either “reasonably” or “very information literate”; the novices self-evaluated their information literacy skills toward the bottom of the scale. This suggests that novices may not have a clear conception of information literacy, since these participants do recognize the deeper structural features of information problems, but do not give themselves credit for it in their self-evaluations.

- There are unexpected results within the low scoring group: the experts all self-evaluated their information literacy skills at the top end of the scale, although their scores suggest that they do not see the nuances of information behaviors that are the deeper structural features of the information problems; similarly, the novices in this group self-evaluated their information literacy skills much more highly than those in the top scoring group, and more highly than novices as a group. Again, this suggests that the participants in both groups may not have a clear conception of information literacy, or one that is not related to standard conceptions described by professional associations. These results may be explained by the Dunning-Kruger effect (Dunning, 2011).
- Within the group of expert high scorers, the range of participant age reflects the total expert group, which was nearly evenly distributed (combining the percentages of those in the 46-55 and 56+ ranges, the totals are both near 50%):
 - 26-35 = 21.4%
 - 36-45 = 28.6%
 - 46-55 = 7.1%
 - 56+ = 42.9%
- The group of novices in both the high scoring and low scoring groups are, as expected, predominantly in the 18-25 range (high scoring group = 75.0%, low scoring group = 81.8%).
- The group of experts in the low scoring group present an unexpected finding in that those in the lowest age range category, 26-35, represent 66.7% of this group; this suggests that age may be a factor in categorical determinations based on deeper structural features, or in task focus.

High Scorers (11-12 on S-D + N-D Comparison Types)								
Participant	Library Experience	Total Score	Gender	Education Level	English Fluency	Library Setting	IL Self-Evaluation	Age
E1	Expert	12	Female	Bachelor	Fluent	Academic	Reasonably IL	56+
E2	Expert	11	Female	Master	Fluent	K-12	Reasonably IL	36-45
E3	Expert	11	Male	Master	Fluent	Public	Reasonably IL	36-45
E4	Expert	11	Female	Master	Fluent	Public	Reasonably IL	26-35
E5	Expert	11	Female	Master	Fluent	Public	Reasonably IL	56+
E6	Expert	11	Female	Master	Fluent	Academic	Very IL	26-35
E7	Expert	11	Female	Master	Fluent	Academic	Very IL	56+
E8	Expert	11	Male	Master	Fluent	Academic	Very IL	56+
E9	Expert	11	Male	Master	Fluent	Public	Reasonably IL	36-45
E10	Expert	11	Female	Master	Fluent	Academic	Very IL	56+
E11	Expert	11	Female	Master	Fluent	Public	Very IL	46-55
E12	Expert	11	Female	Master	Fluent	Public	Reasonably IL	36-45
E13	Expert	11	Female	Master	Fluent	Public	Reasonably IL	26-35
E14	Expert	11	Female	Master	Fluent	Academic	Reasonably IL	56+
N1	Novice	12	Female	High Sch	Fluent	None	Somewhat IL	18-25
N2	Novice	11	Female	Master	Fluent	None	Reasonably IL	36-45
N3	Novice	11	Male	High Sch	Fluent	None	Not IL	18-25
N4	Novice	11	Male	High Sch	Fluent	None	Reasonably IL	18-25

Table 4.3.5A High Scorers (11-12 on S-D + N-D Comparison Types)

Low Scorers (0-3 on S-D + N-D Comparison Types)								
Participant	Library Experience	Total Score	Gender	Education Level	English Fluency	Library Setting	IL Self-Evaluation	Age
E130	Expert	2	Male	Master	Fluent	Academic	Very IL	26-35
E129	Expert	2	Female	Master	Fluent	Public	Reasonably IL	26-35
E128	Expert	3	Female	Master	Fluent	Academic	Reasonably IL	26-35
E127	Expert	3	Female	Master	Fluent	K-12	Very IL	26-35
E126	Expert	3	Female	Master	Fluent	Academic	Reasonably IL	36-45
E125	Expert	3	Male	Master	Fluent	Academic	Very IL	56+
N78	Novice	1	Male	Bachelor	Fluent	None	Reasonably IL	36-45
N77	Novice	1	Male	High Sch	Fluent	None	Somewhat IL	18-25
N76	Novice	2	Male	High Sch	Fluent	None	Reasonably IL	18-25
N75	Novice	2	Male	High Sch	Fluent	None	Reasonably IL	18-25
N74	Novice	3	Male	Bachelor	Fluent	None	Reasonably IL	36-45
N73	Novice	3	Female	High Sch	Fluent	None	Somewhat IL	18-25
N72	Novice	3	Female	High Sch	Fluent	None	Reasonably IL	18-25
N71	Novice	3	Male	High Sch	Fluent	None	Somewhat IL	18-25
N70	Novice	3	Female	High Sch	Fluent	None	Reasonably IL	18-25
N69	Novice	3	Female	High Sch	Fluent	None	Somewhat IL	18-25
N68	Novice	3	Male	High Sch	Fluent	None	Somewhat IL	18-25

Table 4.3.5B Low Scorers (0-3 on S-D + N-D Comparison Types)

4.4 Categorization of Experts and Novices in Other Domains

In this section, the following hypothesis is examined:

(H3) Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.

Do domain experts rely on deep structural features of problem scenarios to categorize problems compared to novices across domains? The null hypothesis to be tested is that there is no significant difference between experts and novices in the selection of analog scenarios with deeper structural feature similarities to a target scenario in novel domains. This hypothesis is tested first in this section.

Do experts rely on deep structural features of problem scenarios to categorize problems compared to novices in the domain of everyday life information? In the domain of statistics? Do experts rely on deep structural features of problem scenarios to categorize problems across domains? These related questions are examined later in this section.

4.4.1 Preliminary Analysis of Domain Types

Everyday Life Information, Librarianship, and Statistics

In this research, novel domains have been operationalized as any other than librarianship. Those selected for inclusion in this study are everyday life information and statistics. This research tests the hypothesis of information problem-solving expert categorization of information problems based on deeper structural feature similarity, a characteristic of expert behavior revealed in the literature. Given the characterization of information literacy as a domain-general set of skills, the research design included two additional sets of triad judgment tasks with information problem

scenarios set in these contexts. The literature from cognate fields is inconclusive on the issue of problem-solving transfer. However, there is some evidence that transfer is facilitated when applied to novel problems within a familiar content domain, or to problems within a near domain; that is, a domain with concepts that are similar to those within the expert's domain. For this research, the domain of everyday life information, which includes the concepts of financial systems, travel information, and consumer advocacy, serves as the near domain. It was expected that these concepts were familiar to participants in both groups, so that the questions of transfer of information problem-solving skill and differences between experts and novices in that transfer could be analyzed. The domain of statistics serves as the far domain; that is, the domain with a conceptual framework that is likely to be unfamiliar to participants in both groups.

The research design included only one comparison type in these domain contexts, S-D, which provides a straightforward choice for participants between an analog with only surface feature similarity (S) or one with only deeper structural feature similarity (D). Therefore, in this stage of the research, the variable of comparison type is held constant so that differences between experts and novices in the domain of librarianship as they make categorical determinations outside of this domain may be analyzed.

In the online triad judgment tasks, participants first completed all tasks with information problem scenarios related to the domain of librarianship. Six tasks with information problems related to the domain of everyday life information appeared next. Participants scored a point for each selection of the analog scenario with the deeper structural feature similarity (D); a total of six points was possible. Six tasks with information problems related to the domain of statistics then appeared. Again, participants could earn a total of six points for selecting the D analog.

The domain of everyday life information was selected for two reasons: 1) it served as the “near domain” for the expert group, so that their transfer of expertise may be facilitated, and 2) it offered the opportunity to serve as a domain in which librarianship novices could be operationalized as experts. In other words, both groups were expected to perform as experts in this domain, and select the D analog in each task. Similarly, the domain of statistics was selected to serve as the “far domain,” and served as a domain in which none of the participants in either group could be operationalized as experts. It was expected that all participants would select the S analog in each of these tasks, earning a score of 0.

Table 4.4.1A shows the predicted percentage of D analog selection in each domain set. The total reflects the percentage of times the D analog was selected for all S-D triad judgment tasks; there were 6 in each domain for a possible score of 18. In no case did participants perform as expected, suggesting a nuanced interpretation of categorical determinations. Domain experts do not appear to categorize information problems strictly according to deeper structural feature in any domain, just as novices do not appear to categorize strictly according to surface feature similarity in any domain. However, the differences are apparent, and intriguing.

The overall frequency of D analog selection, or categorization based on deeper structural feature similarity, for experts is 57%. The frequency of D analog selection in the domain of statistics, at 46%, is much lower than that in everyday life information at 66%. The frequency of D analog selection in the expert group’s domain of expertise, librarianship, is 58% by comparison. While lower in each case, the frequencies for the novice group follow a similar trend: 34% in statistics is lower than 49% in everyday life information, with 41% in librarianship.

Domain	Librarianship Expertise	
	Experts	Novices

	Predicted % D	Observed % D	Predicted % D	Observed % D
Librarianship	100	58	0	41
Everyday Life Information	100	66	100	49
Statistics	0	46	0	34
Total		57		41

Table 4.4.1A: Predicted and Observed Scores

Although outcomes in both domains are closer than expected, the expert group did meet expectations by selecting D analogs more frequently than those in the novice group. Since participants in both groups were given six triad judgment tasks in each domain (all S-D comparison types), random selection would result in a score of 3. Therefore, the means for each group may be examined in terms of whether participants selected the D analog more often than random selection, or less often (greater than or less than 3.00). The means calculated for each comparison type in Table 4.4.1B corroborate this pattern. The next step is to determine if group differences are significant.

Domain	Librarianship Expertise	Mean	Std. Deviation	N
Librarianship	Novice	2.46	1.718	78
	Expert	3.50	1.556	130
	Total	3.11	1.692	208
Everyday Life	Novice	2.92	1.822	78
	Expert	3.98	1.696	130
	Total	3.58	1.813	208
Statistics	Novice	2.06	1.840	78
	Expert	2.78	1.868	130
	Total	2.51	1.886	208

Table 4.4.1B: Descriptive Statistics for Domain Performance

The pattern of expert and novice categorical determinations in each domain is clarified when the means are plotted on a scale comparing group means for performance in each domain (Chart 4.4.1). The means for the expert group are higher than those for the novice group in all three

domains. The gain in mean is greater in the second domain, everyday life information, although both groups performed better than in the domain of librarianship. This result may support the hypothesis that the domain of everyday life information is one in which participants in both groups behave like experts in making categorical determinations. However, expert performance in the domain of librarianship is lower than expected—it was anticipated that experts would select the D analog in both domains of librarianship and everyday life information. The plot lines do not intersect, but they are not parallel either, indicating that there may be a small but likely insignificant interaction effect of expertise and domain. The next statistical analysis will test for this interaction.

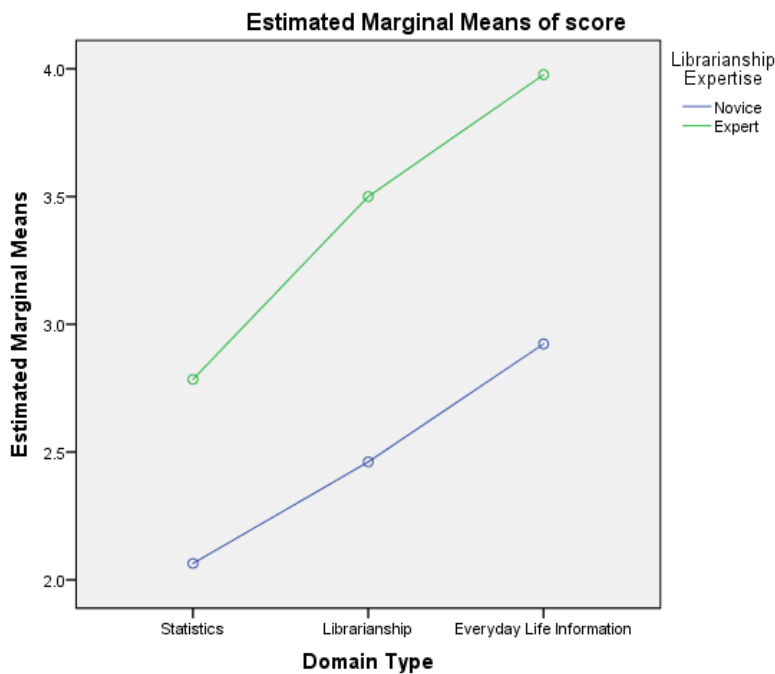


Chart 4.4.2: Estimated Marginal Means of Domain Performance

4.4.2 Statistical Analysis of Domain Types

Everyday Life Information, Librarianship, and Statistics

A 2-factor (expertise) x 3 (domain type) split-plot analysis of variance (ANOVA) was calculated to test the null hypothesis, that there is no significant difference in means between the experts and novices in the selection of analog scenarios with deeper structural feature similarities in the domains of librarianship, everyday life information, and statistics. Factor A is expertise with two levels: expert or novice; it is a between-subjects measure. Factor B is domain with three levels; this is the repeated measures, within-subjects factor. The dependent variable is the performance score in each of the three domains; participants were given a point for each selection of the D analog, that is, the analog scenario that matched the target scenario in deeper structural features. There were six triad judgment tasks in each domain, so a total score of 6 was possible. All triad judgment tasks were of the S-D comparison type.

First, some of the assumptions made in the following statistical analysis were tested. Levene's Test of Equality of Error Variances yielded non-significant results, $F(1, 206) = 2.59, p(.109) > .05$; $F(1, 206) = 2.66, p(.104) > .05$; $F(1, 206) = .002, p(.969) > .05$, meaning that the assumption of homogeneity of variance was not violated. Since Box's M (5.645) was not significant either, $p(.476) > \alpha(.001)$, there are no significant differences between the covariance matrices, and the required assumptions for the ANOVA have not been violated.

The Effect of Domain Type

The test found significance in the main effect of domain type, $F(2, 205) = 35.014, p < .05, \eta^2 = .145$. The η^2 multivariate result indicates that approximately 15% of multivariate variance of the dependent variable is associated with domain type, a large effect size (Cohen, 1988). This indicates that both groups combined scored significantly differently from one domain to the next; in other words, this effect indicates that if we ignore whether the score came from an expert or a

novice, the scores in each domain significantly differed. Although the plot suggested that this was the case, the result is surprising since it was expected that experts would select the D-analog regardless of domain in the first two domain types, librarianship and everyday life information. Note that when Bonferroni corrections are applied to post hoc pairwise comparisons, scores in all three pairings were significantly different. In other words, the degree to which either experts or novices make categorical determinations based on deeper structural feature similarity will depend in part on the domain in which those determinations are made.

The Effect of Librarianship Expertise

Also significant is the main effect of expertise, $F(1, 206) = 20.82, p < .05, \eta^2 = .092$. The partial eta multivariate result indicates that approximately 9% of multivariate variance of the dependent variable is associated with expertise, a medium effect size (Cohen, 1988). This indicates that scores for all domains are significantly different for experts and novices, although only a small portion of the variance may be attributed to expertise; in other words, if we ignore the domain type, scores for experts and novices differed significantly. Again, the plot suggested that this would be the case, so this result is not surprising since it was expected that there would be a significant difference in performance between experts and novices, regardless of domain condition. The fact that neither main effect seems to be associated with the variance to a large degree suggests that there are other factors in play.

The Interaction Effect of Domain Type x Expertise

However, the interaction of the main effects was non-significant, $F(2, 205) = 1.176, p = .310, \eta^2 = .006$. In other words, the magnitude of either main effect is not related to the other. Expert

selection of the D-analog improved more dramatically from the domain of librarianship to that of everyday life information than novice selection.

The relevant hypothesis, based on the second key research question, states:

- (H3) Experts in information problem-solving will choose deeper structural features in categorization of information problems, even with information problems in novel domains.

The preceding results are based on a comparison of the performance of experts in the domain of librarianship to the performance of novices in three domains. Test results indicate that the difference is indeed significant for the main effects of expertise and domain. The null hypothesis, that there is no significant difference between means for the experts and novices in the selection of analog scenarios with deeper structural feature similarities to a target scenario in novel domains, may be rejected.

These results are consistent with the preliminary analysis indicating that there are significant differences in the categorical determinations made by experts and novices across domains.

However, there is no evidence to support an interaction effect, that expertise will have an impact on categorical determination differences between groups from one domain to the next. However, these results do suggest that further research is needed to determine if librarianship expertise provides an “extra boost” in information problem-solving in other domains.

4.4.3 Statistical Analysis of Domain Types: Another Perspective

The analysis in the previous section was performed to test the effects of a between-subjects variable, expertise, in combination with a within-subjects variable, domain type. This enabled an examination of each of the main effects, and the interaction of those effects.

There is another way to look at this data to test the initial hypothesis. Rather than compare scores from the expert group with scores from the novice group, it may be useful to compare scores against random selection of analog scenarios in each of the three domain areas. In other words, instead of comparing expert scores in each of the three domains to novice scores, expert scores in each domain may be compared to the expected score of a participant selecting an S- or D-analog scenario completely at random. This will serve to determine if experts select D analogs more frequently than random selection. Similar tests may be run for the novice group. In this case, it would be expected that each expert would score a 6, and that someone selecting at random would score a 3. This analysis will enable focus on expert categorical determinations, and provide an answer to the following question:

- Do experts rely on deep structural features of problem scenarios to categorize problems even in novel domains?

In this approach, a series of one-sample t-tests were performed, with a Bonferroni correction applied to each (Table 4.4.3). The Bonferroni correction is conservative in minimizing the risk of a Type I error; for these six planned comparisons, a significance level of $p < .008$ was applied to maintain the experiment-wide Type I Error level at $p < .05$.

The null hypothesis in the first test (test 1) is that experts do not make categorical determinations for information problem scenarios based on deeper structural feature similarities within the domain of statistics. The results were not significant for this test condition, $t(129) = -1.315$, $p = .191$; therefore, the null hypothesis may not be rejected. Within the domain of statistics, this sample of information problem-solving experts did not make categorical determinations based upon deeper structural features in a statistically different way than random selection. This is an

expected result, since statistics is not the domain expertise of this sample. However, it may be expected that within a novel domain that information problem-solving experts may be drawn to the S analog; that is, the analog with the surface feature similarity. For this participant sample, selection did not seem to be drawn to either analog type in a statistically significant way.

The null hypothesis may be rejected for the second test condition (test 2), when the domain is librarianship, $t(129) = 3.663$, $p < .008$. The significance is in a positive direction, indicating selection of the D analog. This supports the hypothesis that experts in the field of librarianship make categorical determinations of information problems within their domain based on deeper structural features, whether compared to domain novices or to random selection.

For the third test condition (test 3), when the domain is everyday life information, the null hypothesis may also be rejected, $t(129) = 6.569$, $p < .008$. The significance is in a positive direction, indicating selection of the D analog. Again, this sample of experts in the field of librarianship also made categorical determinations of everyday life information problems based upon deeper structural features.

It was expected that the experts in this sample would select the D analog in both the domain of librarianship and everyday life; however, it is unclear why their scores within the domain of librarianship are lower than those within the domain of everyday life information, given that the possible distractions of surface feature similarity were the same in both measures.

Novice Tests

To further understand categorical determinations under these conditions, the same series of t-tests were performed with the novice group. It was expected that participants operationalized as information problem-solving novices would make categorical determinations based upon surface

feature similarity within the domains of statistics and librarianship, with those within the domain of everyday life information looking more like the experts.

Analysis of novice performance reveals an interesting pattern. In these tests, the null hypothesis is that novices do not make categorical determinations for information problem scenarios based on deeper structural feature similarities within each domain condition. Actually, it is expected that in each of the domain measures, novices would select the S analog; that is, the analog with the surface feature similarity, and receive a score of 0. So, for these tests, the direction of a significant result will be of interest in this analysis. Non-significant results would suggest that novices are not making categorical determinations based on either surface or deeper structural features, but rather in a random fashion.

Within the domain of statistics, the result was significant, $t(77) = -4.492, p < .008$; the negative direction suggests that novices drawn to the analog with the surface feature similarity. This is also true for the domain of librarianship, $t(77) = -2.767, p (.007) < .008$. Therefore, the null hypothesis may be rejected for each of these test conditions.

In the third condition of information problem scenarios within the domain of everyday life information, it was expected that novices perform more like experts, and select the D analog. However, this result was not significant; participants in this sample may have selected analogs based upon deeper structural features more frequently than in the other conditions, but not more often than random selection.

Librarianship Expertise	Domain	Random Selection Mean	Observed Mean	Observed Std. Deviation	t	p value
Expert (n=130)	Statistics	3.00	2.78	1.868	-1.315	.191
	Librarianship	3.00	3.50	1.556	3.663	< .008

	Everyday Life Information	3.00	3.98	1.696	6.569	< .008
Novice (n=78)	Statistics	3.00	2.06	1.840	-4.492	< .008
	Librarianship	3.00	2.46	1.718	-2.767	< .008
	Everyday Life Information	3.00	2.92	1.822	-.373	.710

Table 4.4.3: Comparison of Expert and Novice Scores to Random Selection

4.4.4 Exploratory Case Analyses: Domain Performance

Who were the top scorers? Who were the bottom scorers?

Once again, it will be useful to take a closer look at performance extremes: those experts who scored a perfect 18 on those S-D triad judgment tasks in all domains, and those that scored a zero. Similarly, it will be useful to compare these groups with corresponding groups from the novice sample. While it was expected that the top scorers would be represented by participants in the expert group, this was not necessarily the case. Similarly, the participants with the lowest scores were not all from the novice group.

To make equivalent comparisons, participants from each group that performed the same at the top and at the bottom were compared. Comparing the top 10 scorers at each end may yield wildly different scores and likely render any comparison meaningless. Therefore, by manipulating the criterion for qualification as a “high scorer” (15-18 out of 18 total possible points) and as a “low scorer” (0 out of 18 possible points), it is possible to create two groups that are nearly equal in size for comparison (n=19 for the high scoring group and n=18 for the low scoring group). Many factors could contribute to the outcomes presented in this section, as they represent participant outliers. Therefore, this analysis is exploratory.

The following observations are apparent from a comparison of high (Table 4.4.4A) and low scorers (Table 4.4.4B) from each sample group:

- Differences between experts and novices in terms of the numbers represented in the high and low scoring groups are more pronounced than they were in the comparison type analysis; many more experts in the top scoring group (84.2%), and more novices in the low scoring group (64.7%).
- Within the top scoring group, all of the experts reported having earned a master's degree, and all of the novices reporting having earned a high school diploma or equivalent. These results are the same in the low scoring group, with the exception of the two novices reporting having earned bachelor's degrees appearing once again in the low scoring group; it was expected that these participants would be included in the low scoring group for S-D domain totals.
- Of the 7 participants reporting "developing fluency in English" within the entire sample of 208 participants, one was the top scorer in the novice group.
- Of the 19 top scorers in both groups, 78.9% were female, which is slightly higher than the 69.7% proportion of female to males in the total sample group; whereas, in the low scoring group, only 50.0% were female.
- Of the expert participants in both high and low scoring groups (n=24), library setting experience was representative of the entire sample: academic (41.7%), public (45.8%), and K-12 school (12.5%).
- Within the top scoring group, the experts all self-evaluated their information literacy skills at the top end as either "reasonably" or "very information literate"; the novices

self-evaluated their information literacy skills slightly lower as either “somewhat” or “reasonably information literate.”

- The pattern revealed in the prior case analysis is evident again within the low scoring group: the experts all self-evaluated their information literacy skills at the top end of the scale, although their scores suggest that they do not see the nuances of information behaviors that are the deeper structural features of the information problems; similarly, the novices in this group self-evaluated their information literacy skills more highly than novices as a whole (none in this group self-evaluated their skills at the lowest end of the scale as “not information literate, although 19.2% did so in the entire novice sample group). Again, this suggests that the participants in both groups may not have a clear conception of information literacy, or one that is not related to standard conceptions described by professional associations.
- Within the group of expert high scorers, the range of participant age reflects the total expert group, which was nearly evenly distributed (combining the percentages of those in the 46-55 and 56+ ranges, the totals are both near 50%):
 - 26-35 = 25.0%
 - 36-45 = 31.3%
 - 46-55 = 12.5%
 - 56+ = 31.3%
- The group of novices in both the high scoring and low scoring groups are, as expected, predominantly all in the 18-25 range (with the exception of the two low scoring novices in the 36-45 age range).

- Once again, the group of experts in the low scoring group present an unexpected finding in that those in the lowest age range category, 26-35, represent 50.0% of this group.

It is difficult to extrapolate findings with any degree of certainty in these case analyses since these represent the outliers in both sample groups. There are many reasons to explain an extremely high or low score that may have little to do with the participant’s categorical determinations. Interestingly, random selection is not one of them, as this should result in scores at the median; that is, participants who selected analogs at random should have selected the D-analog as often as not. The triad judgment tasks in this analysis were all of the S-D comparison type. Therefore, it is possible that these participants followed a strategy for categorical determination that resulted in a high or low score without regard to how they would make such a determination outside of a research setting. For example, a participant could have decided that they would never select an analog with surface feature similarity because they suspected that the researcher was expecting it.

A factor that deserves further consideration from the preceding analysis is age. The following section addresses this factor.

High Scorers (15-18 on S-D Comparisons in All 3 Domains)								
Participant	Library Experience	Total Score	Gender	Education Level	English Fluency	Library Setting	IL Self-Evaluation	Age
E1	Expert	18	Female	Master	Fluent	Academic	Very IL	26-35
E2	Expert	16	Female	Master	Fluent	Public	Reasonably IL	56+
E3	Expert	16	Male	Master	Fluent	Academic	Very IL	56+
E4	Expert	16	Female	Master	Fluent	Academic	Very IL	56+
E5	Expert	16	Female	Master	Fluent	Public	Very IL	46-55
E6	Expert	16	Female	Master	Fluent	K-12	Reasonably IL	56+
E7	Expert	16	Male	Master	Fluent	Public	Reasonably IL	46-55
E8	Expert	16	Female	Master	Fluent	K-12	Very IL	56+
E9	Expert	16	Female	Master	Fluent	Academic	Very IL	26-35
E10	Expert	15	Female	Master	Fluent	K-12	Reasonably IL	36-45
E11	Expert	15	Female	Master	Fluent	Public	Reasonably IL	26-35
E12	Expert	15	Female	Master	Fluent	Public	Very IL	36-45
E13	Expert	15	Female	Master	Fluent	Public	Reasonably IL	26-35

E14	Expert	15	Female	Master	Fluent	Academic	Very IL	36-45
E15	Expert	15	Female	Master	Fluent	Academic	Very IL	36-45
E16	Expert	15	Female	Master	Fluent	Public	Very IL	36-45
N1	Novice	18	Male	High Sch	Develop	None	Somewhat IL	18-25
N2	Novice	15	Male	High Sch	Fluent	None	Somewhat IL	18-25
N3	Novice	15	Female	High Sch	Fluent	None	Reasonably IL	18-25

Table 4.4.4A High Scorers (15-18 on S-D Comparisons in All 3 Domains)

Low Scorers (0 on S-D Comparisons in All 3 Domains)								
Participant	Library Experience	Total Score	Gender	Education Level	English Fluency	Library Setting	IL Self-Evaluation	Age
E130	Expert	0	Female	Master	Fluent	Public	Very IL	36-45
E129	Expert	0	Male	Master	Fluent	Public	Reasonably IL	56+
E128	Expert	0	Female	Master	Fluent	Public	Very IL	26-35
E127	Expert	0	Female	Master	Fluent	Academic	Very IL	36-45
E126	Expert	0	Female	Master	Fluent	Academic	Reasonably IL	26-35
E125	Expert	0	Male	Master	Fluent	Academic	Very IL	56+
E124	Expert	0	Male	Master	Fluent	Academic	Very IL	26-35
E123	Expert	0	Female	Master	Fluent	Public	Reasonably IL	26-35
N78	Novice	0	Male	Bachelor	Fluent	None	Reasonably IL	36-45
N77	Novice	0	Male	High Sch	Fluent	None	Reasonably IL	18-25
N76	Novice	0	Male	High Sch	Fluent	None	Reasonably IL	18-25
N75	Novice	0	Male	Bachelor	Fluent	None	Reasonably IL	36-45
N74	Novice	0	Female	High Sch	Fluent	None	Somewhat IL	18-25
N73	Novice	0	Female	High Sch	Fluent	None	Reasonably IL	18-25
N72	Novice	0	Female	High Sch	Fluent	None	Somewhat IL	18-25
N71	Novice	0	Male	High Sch	Fluent	None	Somewhat IL	18-25
N70	Novice	0	Male	High Sch	Fluent	None	Somewhat IL	18-25
N69	Novice	0	Female	High Sch	Fluent	None	Somewhat IL	18-25

Table 4.4.4B Low Scorers (0 on S-D Comparisons in All 3 Domains)

The next section initiates an exploratory analysis of the effect of age on categorical determinations.

4.5 Special Consideration: An Exploratory Analysis of Age

The research design of this study called for recruitment of participants from the pool of students enrolled in undergraduate courses at the University of Washington to be placed in the novice group; those placed in the expert group were recruited from the pool of trained and experienced librarians in practice within Washington State. Since most of the participants in the novice group

are under 25 years of age, and most of those in the expert group are over 25 years of age, a challenge to internal validity is the effect of age on categorical determinations. By the mere fact of more time in a professional setting, faced with a myriad of information problem-solving experiences, it could be argued that expert and novice differences could be more closely related to age than training and experience in the field of librarianship.

To examine this area, some exploratory analysis was conducted.

Age * Librarianship Expertise Crosstabulation

		Librarianship Expertise		Total	
		Novice	Expert		
Age	18-25 years old	Count	71	0	71
		% within Librarianship Expertise	91.0%	0.0%	34.1%
	26-35 years old	Count	1	24	25
		% within Librarianship Expertise	1.3%	18.5%	12.0%
	36-45 years old	Count	4	33	37
		% within Librarianship Expertise	5.1%	25.4%	17.8%
	46-55 years old	Count	1	31	32
		% within Librarianship Expertise	1.3%	23.8%	15.4%
	56 or more years old	Count	1	42	43
		% within Librarianship Expertise	1.3%	32.3%	20.7%
Total		Count	78	130	208
		% within Librarianship Expertise	100.0%	100.0%	100.0%

Table 4.2.3C: Comparison of Participant Age and Librarianship Expertise

This section of analysis is exploratory because it involves analyzing data from samples that were recruited for a different purpose. To ensure that participants in the novice group did not have training or experience in the field of librarianship, undergraduates were recruited; 91% of these participants reported themselves as between the age of 18-25 years old. By contrast, participants recruited for the expert group would have had to complete a graduate program in library and information science. As would be expected, 100% of these participants reported themselves as

over 25 years of age. So, when combined to conduct a series of test based upon age, the older participants have experience in librarianship, and the younger participants do not. As is the nature of exploratory analysis, it will be interesting to forge ahead and examine the results.

The researcher's hypothesis is that experts in the domain of librarianship will select analog scenarios with a deeper structural feature similarity (D-analog) in triad judgment tasks that include an S-analog and a D-analog, whereas novices will select analog scenarios with surface feature similarity (S-analog), even when the difference in means are adjusted for the covariate of age. As a result of the research design, the expert and novice participant samples differed not only in librarianship training and experience, but also in age. The statistical challenge is to determine if differences in categorical determinations could be due to the simple fact that there are differences in age, and thus, life experience. But once we control for age, do experts still make categorical determinations based on deeper structural features more frequently than novices?

ANCOVA

An analysis of covariance will re-estimate the means between experts and novices in scores to account for the effect of the covariate, age. It provides us with an unbiased mean—not biased by the effect of age. In other words, the ANCOVA estimates a hypothetical mean that would not be biased toward the effects of the covariate of age. Then the determination may be made of whether the difference in score means of experts and novices is still statistically significant.

First, an ANCOVA was run with the composite S-D scores across domain types. As you may recall, the results of the analysis of variance test the difference in means for total scores of all S-D comparison types resulted in a rejection of the null hypothesis, $F(1, 206) = 20.82, p < .05, \eta^2 =$

.092; the partial eta multivariate result indicates that approximately 9% of multivariate variance of the dependent variable is associated with expertise. When the analysis of covariance test is run with age as the covariate, the differences in covariances is statistically significant; in other words, there was a significant effect of librarianship experience on categorical determinations based on deeper structural features after controlling for the effect of age, $F(1, 205) = 7.68$, $p(.006) < .05$, $\eta^2 = .036$, although the effect size is small (Cohen, 1988). The covariate, age, was not significantly related to score, $F(1, 205) = .034$, $p = .855$. Moreover, Levene's Test of Homogeneity of Variances is non-significant, $F(1, 206) = .314$, $p = .576$, so the samples have equal variances.

In addition to the same assumptions necessary for the analysis of variance, there are two assumptions that must be made for the analysis of covariance for the results to be accurate: 1) independence of the covariate and independent variable, and 2) homogeneity of regression slopes. First, the assumption of homogeneity of regression holds, given that interaction effect of librarianship experience and age is non-significant, and fails to reject the null hypothesis of homogeneity, $F(1, 204) = .085$, $p = .771$. The other assumption, however, has been violated in this analysis. When the analysis of variance test is run on the dependent variable of score and the independent variable of age, there is a significant difference, $F(4, 203) = 5.09$, $p = .001$. Therefore, the effect of age on categorical determinations based on age cannot be ruled out. Further research is needed to investigate the effect of life and professional experience of a general nature on categorical determinations based on deeper structural features.

Drilling Deeper: Domain Differences

Next, the ANCOVA tests were run for S-D scores in each of the domain areas. In each, the result was significant and the null hypothesis that the means of the expert and novice sample groups are similar may be rejected. While there are significant differences in categorical determinations based on deeper structural features between the expert and novice sample groups in each of the three domains, these significances are slight when age is accounted for, indicating some sort of influence of age on these determinations.

For the first test, the independent variable was librarianship experience, the dependent variable was score on the S-D comparison type in the **domain of librarianship** (possible score = 6), and the covariate was age. The result was significant, $F(1, 205) = 5.268$, $p = .023$, $\eta^2 = .025$ (small effect size). The covariate age was non-significant, $F(1, 205) = .439$, $p = .508$. Levene's Test was non-significant, $F(1, 206) = 2.461$, $p = .118$.

For the second test, the independent variable was librarianship experience, the dependent variable was score on the S-D comparison type in the **domain of everyday life information** (possible score = 6), and the covariate was age. The result was significant, $F(1, 205) = 4.812$, $p = .029$, $\eta^2 = .023$ (small effect size). The covariate age was non-significant, $F(1, 205) = .340$, $p = .561$. Levene's Test was non-significant, $F(1, 206) = 2.36$, $p = .126$.

For the third test, the independent variable was librarianship experience, the dependent variable was score on the S-D comparison type in the **domain of statistics** (possible score = 6), and the covariate was age. The result was significant, $F(1, 205) = 5.052$, $p = .026$, $\eta^2 = .024$ (small effect size). The covariate age was non-significant, $F(1, 205) = .496$, $p = .482$. Levene's Test was non-significant, $F(1, 206) = .005$, $p = .946$.

Another Approach: All Participants, All S-D Comparison Types, With Age as the Independent Variable

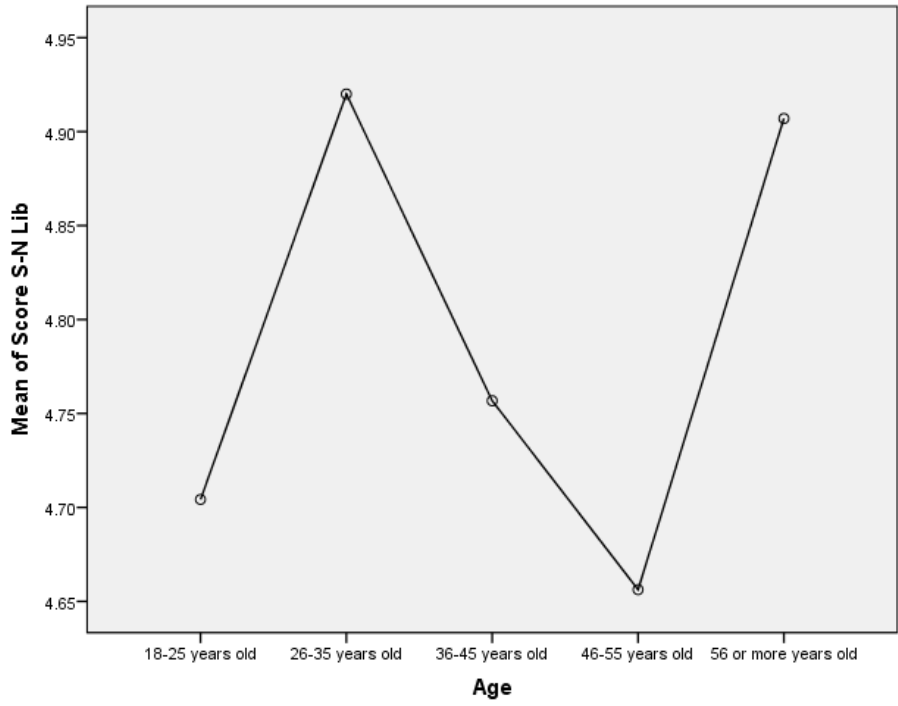
Another way to examine the differences that age may have on categorical determinations is to re-examine the data with a focus on age as the independent variable. The most logical test is an overall test comparing age in combined scores for all S-D comparison types. This approach takes into account the largest sets of data: responses on all S-D comparison types (18 S-D triad comparisons) from participants in both sample groups (n=208). A one-way analysis of variance test will tell us if there is at least one statistically significant difference in means between two of the groups. A one-way ANOVA was performed with the factor of age and the dependent variable performance within the S-D comparison type from all three domains; that is, the selection of the D-analog. A perfect score of 18 is possible. The result of the test indicates that there is a statistically significant difference in the means between at least two of the groups, $F(4, 203) = 5.093, p = .001$. Pairwise comparison tests with Bonferroni corrections reveal expected differences between the 18-25 group and the 46-55 group (near significance with the 56+ group). Levene's test was found to be non-significant, supporting the assumption of homogeneity of variances, $F(4, 203) = 1.799, p = .130$.

For comparison, a similar test was run for all N-D comparison types (6 N-D triad comparisons), and all S-N comparison types (6 S-N triad comparison types). A one-way ANOVA was performed with the factor of age and the dependent variable performance within the N-D comparison type, which was only run in the domain of librarianship. A perfect score of 6 is possible. Again, this is simply a test to determine if there is a difference in means when the samples are organized by age. The result of the test indicates that there is a statistically significant difference in the means between at least two of the groups, $F(4, 203) = 3.478, p =$

.009. Pairwise comparisons using the Bonferroni correction identified a significant difference only between the 18-25 group and the 56 or more group. Levene's test was found to be non-significant, supporting the assumption of homogeneity of variances (1.709).

A similar result was found with the test for the S-N comparison type, but with a very different result. The result of this test indicates that there is not a statistically significant difference in the means between any of the groups, $F(4, 203) = .338, p = .852$. Once again, Levene's test was found to be non-significant, supporting the assumption of homogeneity of variances (1.209).

This result is difficult to analyze, however, because in the S-N comparison type, the score was determined by selection of the S-analog for comparison purposes, and cannot be analyzed in a way similar to the other comparison types, where there was a D-analog to select. Therefore, this result means that in the absence of a D-analog, participants are making categorical determinations based on surface feature similarity, or by random selection, regardless of age. This means plot suggests that this is the case.

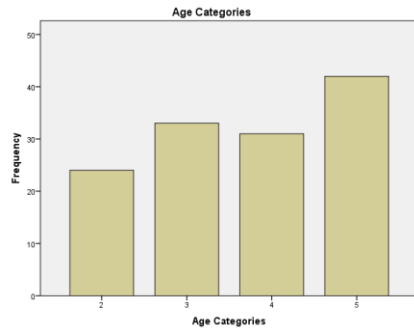


Looking at the Expert Sample: Age Differences?

Another perspective on the issue of age with this data set is to look at score differences within the expert group. In other words, given librarianship training, does experience matter in categorical determinations?

For this test, an analysis of variance was run on those in the expert group only ($n = 130$); in effect, controlling for expertise. There was not a significant difference in means among the age category sample groups, $F(3, 126) = .972, p = .408$. Levene's Test was non-significant, $F(3, 126) = 1.952, p = .125$. One way to interpret this result is that age, or possibly experience within the field of librarianship, does not seem to affect categorical determinations in a situation where all participants have had librarianship training.

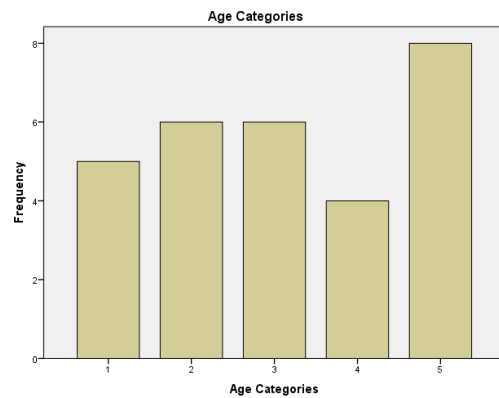
The chart below shows the frequency distribution in age categories for the expert sample group.



There is nothing to be revealed by a similar examination of the novice group since nearly all ($n = 71$) of the total sample ($n = 78$) are in the 18-25 age group.

High-Low Scorers, All S-D Comparison Types

It may be revealing to examine the high scorers and the low scorers to identify expected patterns. Of the high scorers (14 or better out of 18 S-D comparison types across all three domains), 25 are from the expert group (librarianship training and experience) and 4 are from the novice group (no training or experience). This set of high scorers is predominantly expert. However, it is interesting to note that there



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The same test was run for all participants scoring 5 or 6 (out of 6) on each of the S-D comparison types separately, one set of six triad judgment tasks from each of the domain areas. The same test was run with participants who scored 1 or zero.

Isolating Outliers

It is possible that participants made categorical determinations according to a detected pattern or expectation rather than an actual determination based on problem similarities. Participants may have been familiar with the triad judgment task method, or were predisposed to look for deeper structural feature similarities because of prior knowledge of the tasks; on the other hand, participants may also have selected the analogs with surface feature similarity as a rule, rather than as a judgment, simply to complete the tasks more quickly, or because they were following a pattern. While it may be that certain participants made categorical determinations in a consistent manner for each of the triad judgment tasks and did not follow a selection strategy, it may be informative to run these tests excluding outliers for the sake of comparison.

Those participants earning a score of 18 out of 18 ($n = 2$) and those earning a score of 0 out of 18 ($n = 18$), were excluded from the sample data and the tests were run again.

Other Confounds: Gender, Education, IL Self-Rating

Next, the ANCOVA tests were run for total S-D scores (composite score for S-D comparison types in all three domains), considering the covariate effects of gender, education, and information literacy self-rating.

For the first test, the independent variable was librarianship experience, the dependent variable was total score for all S-D comparison types (possible score = 18), and the **covariate was**

gender. The result was significant, $F(1, 205) = 18.587, p < .05, \eta^2 = .083$ (medium effect size). The covariate gender was non-significant, $F(1, 205) = .026, p = .872$. Levene's Test was non-significant, $F(1, 206) = .329, p = .567$.

For the second test, the independent variable was librarianship experience, the dependent variable was total score for all S-D comparison types (possible score = 18), and the **covariate was information literacy** self-rating. The result was significant, $F(1, 205) = 10.707, p = .001, \eta^2 = .050$ (small effect size). The covariate information literacy self-rating was non-significant, $F(1, 205) = .012, p = .914$. Levene's Test was non-significant, $F(1, 206) = .334, p = .564$.

For the third test, the independent variable was librarianship experience, the dependent variable was total score for all S-D comparison types (possible score = 18), and the **covariate was education.** The result was non-significant, $F(1, 205) = 2.723, p = .100, \eta^2 = .013$. The covariate age was non-significant, $F(1, 205) = .025, p = .874$. Levene's Test was non-significant, $F(1, 206) = .308, p = .580$.

The results were significant for the covariates of gender and information literacy rating, and the null hypothesis that the means of the expert and novice sample groups are similar may be rejected. While there are significant differences in categorical determinations based on deeper structural features between the expert and novice sample groups in each of the three domains, these significances are slight when age is accounted for, indicating some sort of influence of age on these determinations. For the covariate of education, the result was non-significant, so the null hypothesis could not be rejected in that case; this may have been a pointless test anyway, since it was unlikely that any of the participants recruited for the novice group would have had any post-high school degree at all.

For the most part, this exploratory analysis fails to rule out the effect of age in making categorical determinations based on deeper structural features. However, participant recruitment as described in the research design was expected to result in two large groups at the age extremes.

4.6 Rationale for Categorical Determinations Made by Experts and Novices

The online triad judgment tasks yielded data sufficient to complete a quantitative analysis on the categorical determinations of information problems by experts and novices. This instrument, however, was not designed to collect data revealing the rationale of participants as they made these categorical determinations. The second phase of this study was designed to elicit and record these thought processes as expressed verbally by participants.

Initial contact was made by the researcher via email, and a time and place convenient for the participant to meet was determined. The researcher recruited ten participants for the novice group and ten for the expert group. An additional ten participants were recruited for exploratory analysis; none of these participants had completed the online judgment tasks in the first of the investigation. These participants were recruited to begin an exploration of the role age and education level may play in categorical determinations. Thus, while none met the criteria for the expert group (training and experience in librarianship), and all met the criteria for the novice group, they were selected to formulate a sample group that was distinct from the novice group recruited for the online judgment tasks in that they were all over the age of 35 and reported varying levels of education. Ten participants each from the expert and novice groups were interviewed for investigation 2. In all, responses from 30 participants were analyzed.

Most of the meetings (13) occurred on the campus of the University of Washington. Other locations include neighborhood coffee shops (6), restaurants (5), public schools (2), and private homes (4). Participants were asked to review the Study Information Sheet, affirm their consent (as a formality, as this study was granted exempt status from IRB-HS), and then instructions were given for the sorting tasks. For each round, participants drew three cards at a time randomly from a set (5 draws from the librarianship set, and 3 each from the Everyday Life Information and Statistics sets), read the information problem scenarios, and sorted two that are “more similar” than the third. They then explained why the two were more similar, and how the third was different. The researcher employed a laddering process, or series of questions, to approximate binary constructs. Participant responses to the Investigation 2 sorting tasks were recorded via the RepGrid form.

RepGrid data was analyzed qualitatively using analytic induction, a content analysis approach, to reveal patterns that emerge in participant categorization of information problems in three domains. The focus of this analysis was to describe constructs that emerge in each participant group, and to indicate their relative importance. The researcher expects that this analysis will reveal the cognitive processes of participants during information problem categorization in multiple domains and test hypotheses 2 and 4:

- H2 (RQ 1.2): The thinking processes of experts in information problem-solving during Task Definition are similar to those reported by experts in other domains.
- H4 (RQ 2.2): The thought processes of experts in information problem-solving will reveal a set of domain-general skills that grant a benefit to information problem-solving experts over novices, even in novel domains

4.6.1 Patterns of Data for Repertory Grid Technique

The sorting method used in the preceding investigation is an established method within the field of cognitive psychology to expose complex cognitive processes during categorical determinations of problem scenarios (Hardiman et al, 1989; Hogan & Rabinowitz, 2009). The triad judgment task variation on this method produces data that may be analyzed quantitatively. However, this method does not provide for the reporting of participant thinking during these determinations. The research design includes another component aimed at capturing the thought process of participants in a live setting with the researcher. The RepGrid Technique is an efficient method for capturing this data in a succinct format for qualitative analysis (Tan & Hunter, 2002).

The goal of the RepGrid Technique is to reveal patterns in responses that yield a meaningful profile of target of investigation. These patterns are revealed through a process of identifying the frequency with which certain constructs are offered. The next step was to identify those responses in which a participant was unable to determine a binary construct, and interpret it from the response given. This interpretation was derived from the response recorded for the participant only to most closely approximate the thinking of the participant; the researcher did not consult the scenario cards drawn in that round. Participant response data, including sorting data and construct data, were either copied verbatim, clarified, or interpreted by the researcher onto an Excel spreadsheet for analysis.

A useful feature of the RepGrid Technique is the option for participants to rate the given target on a construct continuum. A typical example would be to rate a manager on a scale between “collaborative decision-making versus independent decision-making.” This process enables a level of quantitative analysis. For investigation 2, however, the constructs in many cases were

simply two different categories and not bound by a measurable continuum. For example, “evaluating performance versus predicting performance.”

According to the laddering process of the RepGrid Technique, participants were asked to make revisions to their sorting strategies until a response approximating a binary construct was determined. For each draw, final sorts and accompanying binary constructs were recorded on the RepGrid form. In many cases, participants were unable to determine a clear binary construct; in these cases, the participant’s final response was recorded.

4.6.2 Measures and Analysis

Data from this phase of the research was analyzed both quantitatively and qualitatively. The first section presents the descriptive statistics analyzed from this data, and the second section presents the verbal reporting of personal constructs analyzed qualitatively

Descriptive Statistics

Results of the analysis of data collected from this second phase of the research include descriptive statistics. The goal of this phase of data collection was to yield participant verbal responses to the rationale used to describe differences between two groups of information problem scenarios. Since participants were asked to draw three cards at a time from each domain set, there was the chance that there would not be an S-D comparison type nor an N-D comparison type in the draw. That is to say, a draw may have consisted of three information problem scenarios that were not similar in terms of deeper structural features in any way—one related to defining the topic, one related to information access, and the third related to information evaluation. Similarly, a draw may have consisted of three of the same deeper structural features, rendering any distinction based on deeper structural feature impossible.

Again, categorical determinations made from these comparison types was not the intent of this phase of data collection; qualitative analysis of the personal construct data will be presented in the next section.

The table below presents the descriptive statistics related to this data set. Participants were recruited for three sample groups: Novice, Expert, and Exploratory. Each participant was asked to draw three cards from each stack of information problem scenarios, representing the domains of librarianship, everyday life situations, and statistics, until all cards were drawn (no scenarios were returned to the stacks). This resulted in 11 total draws per participant, and 110 total draws for each sample group. Table 4.7.2a shows the percentage of groupings with paired D-analogs out of all the situations in which such a grouping was possible for each sample group.

Sample Group	Draws with S-D/N-D Comparison types	Groupings with paired D-analogs (Librarianship)	Groupings with paired D-analogs (Everyday Life Situations)	Groupings with paired D-analogs (Statistics)	Groupings with paired D-analogs (TOTAL)
Novice (n=10)	66%	49%	74%	37%	52%
Expert (n=10)	69%	71%	43%	48%	57%
Exploratory (n=10)	62%	48%	56%	42%	49%

Table 4.7.2a: Sample Group Comparisons of D-Analog Groupings

The number of draws in which D-analog pairings were possible was consistent across all sample groups, ranging from 62-69%. With a focus on these draws (excluding those in which a D-analog pairing was not possible), the expert group paired D-analogs more frequently than the other groups (57% versus 52% and 49%). When a more focused lens is brought to bear on this data; that is, focusing on draws within each domain separately, the expert group still paired D-analogs

more frequently in each group other than the domain of Everyday Life Situations. In that case, the novice group paired D-analogs more frequently than either group.

The purpose of recruiting the third sample group, those over the age of 35 with varying levels of education but no training or experience in librarianship, was to begin an exploratory analysis of the effects of age and education level on categorical determinations based on deeper structural features of information problems. This data reveals that these participants made determinations comparable to those in the novice group. Moreover, they made categorical determinations based on deeper structural features much less frequently than those in the expert group in every domain except for Everyday Life Situations.

In accordance with the research design, data in this phase of the investigation was collected primarily for qualitative analysis. The next section presents these results.

Qualitative Analysis of Verbal Reporting of Personal Constructs

Per the RepGrid Technique protocol, participants were asked to draw three information problem scenarios from a deck. They were then asked to read the scenarios, and pair two that were more similar than the third. Statements describing a) how the paired scenarios were similar, and b) how the third scenario was different from the pair, were elicited. The researcher conducted a laddering procedure during each draw to determine a binary construct; these constructs were recorded for analysis. Participants were asked to draw any three scenarios randomly from a deck corresponding to each of the three domains employed in the study. Therefore, not every draw yielded an opportunity to make a categorical determination based on a deeper structural feature (S-D or N-D comparison types); the other possibilities included a draw of three scenarios with

the same deeper structural feature, and a draw of three scenarios each with a different deeper structural feature.

First, descriptive statistics were calculated, then a type of content analysis, analytic induction, was applied—first a deductive review looking for patterns related to surface feature vs. deeper structural feature similarity grouping and information problem-solving stages, then an inductive analysis looking for new patterns or understandings (Patton, 2010, p. 454). Overall patterns did emerge from these constructs. Participants in all three sample groups typically struggled to group the information problem scenarios according to the protocol; participants typically reiterated the contents of each scenario in their initial sorts. The laddering procedure was applied to nearly every draw with every participant.

An analysis of the final binary constructs reveals that all participants sorted based on either explicit narrative details included in the scenarios, or implied processes related to the information problem-solving process, regardless of comparison type. These constructs often correspond to the surface feature or deeper structural feature similarities examined in the online triad judgment tasks. However, in many cases, a construct that was based on a deeper structural feature did not match the actual feature. A frequency count was calculated for constructs that focused on either narrative details or process-related underlying principles, corresponding to the concepts of surface or deeper structural features in the previous phase, without suggesting correspondence to actual features. Table 4.7.2b shows the frequency counts of constructs for each sample group that are related to either narrative details or underlying principles; there were 110 constructs for each sample group, corresponding to 11 draws for each of the 10 sample group participants.

Sample Group	Constructs related to narrative	Constructs related to underlying principle
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Novice	44	66
Expert	40	70
Exploratory	56	54

Table 4.7.2b Frequency Counts of Construct Relate to Narrative or Underlying Principle

In this phase, participants expressed these categorical determinations verbally, validating the assumption categorical determinations made during Task Definition are often conscious:

“these are about voluntary projects...this is about an involuntary project” (Mick, Novice Group)

“these are about searching for a topic...this is about searching for information about a topic” (Eileen, Novice Group)

“these are about looking for information...this is about evaluating the information they already have” (Samuel, Expert Group)

“these are about high school students...this is about a university student” (Sara, Expert Group)

Thus, this data suggests that metacognition plays a role in Task Definition.

Patterns emerge between the novice and expert sample groups as well. The constructs of participants in both groups focused on underlying principles more frequently than on narrative details in the scenarios related to librarianship and everyday life situations:

“these are about being troubled by how to find the information I need...this is about having the information I need, but needing to know what to do with it” (Joseph, Novice Group)

“these are about deciding between two conflicting offers...this is about acquiring information about an offer” (Janet, Novice Group)

“these are about trying to evaluate choices...this is about not yet identifying a choice” (Karen, Expert Group)

“these are about being higher in the funnel—they don’t know anything...this is about being further down the funnel—they need to know how to use an information source” (Miguel, Expert Group)

The constructs of these groups shifted toward narrative details when asked to sort scenarios related to the domain of statistics:

“the topics are the same in these...this is a different scenario” (Scott, Novice Group)

“these are about skill level...this is not related to skill level, it’s about number of hours slept” (Mary, Novice Group)

“these are about typing...this is about psychology” (Loretta, Expert Group)

“these are about giving a test in the moment where the data will be collected...this is about comparing data that already exists” (Brenda, Expert Group)

The constructs of the participants in the exploratory group were nearly equal in focus on either narrative details (n=54) or implied processes (n=56). However, the constructs of this group also shifted toward a focus on narrative details in the domain of statistics. In terms of frequency counts for either narrative or process-related constructs, the pattern for this sample group is indistinguishable from those of the novice group:

“these are about two students working on assignments...this is about an oncologist working on a patient’s treatment” (Janet, Exploratory Group)

“these are about having plenty of sources of information, but need to determine reliability... this is about not having enough information” (Fred, Exploratory Group)

“these are about financial impacts on your life...this is about a fun leisure trip” (Jeremy, Exploratory Group)

“these are about some research being done and now they have to choose something...this is about no research being done” (Sylvia, Exploratory Group)

“these are both using the same criteria to score people...this one is using different criteria to score people” (Lisa, Exploratory Group)

“these are about two groups being compared...this is about each subject being measured along a range” (Consuela, Exploratory Group)

Personal Construct Correspondence with Categorical Determinations

The third stage of this analysis examines the correspondence of verbalized personal constructs with categorical determinations. In other words, did the grouping of information problem scenarios according to deeper structural features actually correspond to the participant’s conscious recognition of these similarities? Table 4.7.2b includes the percentage of groupings with paired D-analogs out of all the situations in which such a grouping was possible, with a construct that included a deeper structural feature, for each sample group. When constructs that reveal a grouping rationale based on a deeper structural feature are linked to D-analog groupings, the percentages are decreased for each group; however, the rankings are the same—the expert

sample group made categorical determinations based on deeper structural features, when available, more often than the novice group, and both of these groups did so more often than the exploratory group.

Sample Group	Draws with S-D/N-D Comparison types	Groupings with paired D-analogs (Librarianship)	Groupings with paired D-analogs (Everyday Life Situations)	Groupings with paired D-analogs (Statistics)	Groupings with paired D-analogs (TOTAL)	Groupings with paired D-analogs + <i>Process Constructs</i> (TOTAL)
Novice (n=10)	66%	49%	74%	37%	52%	44%
Expert (n=10)	69%	71%	43%	48%	57%	47%
Exploratory (n=10)	62%	48%	56%	42%	49%	34%

Table 4.7.2c Sample Group Comparisons of D-Analog Groupings + Constructs Related to Deeper Structural Feature

There were many cases in which participants grouped two information problem scenarios with D-analog similarity, but the corresponding construct revealed a conscious rationale based on surface, or narrative features. Often (8 out of 17 occurrences), these were scenarios in the domain of statistics:

“these two have meaningful data...this one has less meaningful data” (Joseph, Novice Group, Statistics Domain)

“in these situations, they have evidence...in this one, there is no evidence” (Jack, Exploratory Group, Statistics Domain)

It is interesting to note that, for the expert sample group, in every draw in which D-analog groupings were made, participants in this sample group verbalized a construct that related to a deeper structural feature. In other words, these participants consciously grouped according to deeper structural features, and verbalized this rationale in the form of a construct. This was not the case in the novice and exploratory groups, where participants often made D-analog groupings, but did not express a construct that identified the deeper structural feature similarity.

Given the random configurations facing participants in drawing the information problem scenarios at random, and the small size of the sample groups, distinct profiles did not emerge. However, patterns related to groupings and constructs did emerge across all sample groups. Each participant, regardless of grouping, employed one of the following strategies:

- I. The Expert: constructs reveal a grouping is made based on a similar underlying principle; D-analogs are present and grouped together.
- II. The Deep Thinker: constructs reveal a grouping is made based on perceived underlying principles, but these are not related to the actual underlying principles within the selected information problem scenarios; D-analogs are present, but not grouped together.
- III. The Meaning-Maker: constructs reveal a grouping is made based on perceived underlying principles, but these are not related to the actual underlying principles within the selected information problem scenarios; D-analogs are not present.
- IV. The Novice: in this strategy, constructs reveal a grouping is made based on narrative features of the information problem scenarios; D-analogs are present, but not grouped together.
- V. The Oblivious Grouping: constructs reveal a grouping is made based on narrative features of the information problem scenarios; D-analogs are present, and grouped together.

VI. The Randomizer: constructs reveal a grouping is made based on narrative features of the information problem scenarios; D-analogs are not present.

Grouping Strategy Profiles	D-analog present, grouped together	D-analog present, not grouped together	D-analog not present
Grouping based on underlying principle	The Expert	The Deep Thinker	The Meaning-Maker
Grouping based on narrative feature	The Oblivious Grouper	The Novice	The Randomizer

Table 4.7.2d Grouping Strategy Profiles

Table 4.7.2e shows the frequencies with which these strategies were applied by each sample group.

	Expert	Deep Thinker	Meaning Maker	Novice	Lucky Guesser	Randomizer
Novice	32	15	27	19	6	11
Expert	35	19	22	15	6	13
Exploratory	23	12	22	28	4	21

Table 4.7.2e Grouping Strategy Profiles with Frequencies

Overall, this data serves to corroborate the findings of the first phase of this research. Denzin (1978) applies the term methodological triangulation to the use of more than one method to examine a single problem. The information problem scenarios were constructed with an explicit narrative and an implicit stage in the information problem-solving process. Faced with the task of sorting three scenarios drawn from the deck, participants verbalized their rationales for categorical determinations based on these explicit or implicit elements. Therefore, a more open-ended interpretation of the sorting task was not possible. Thus, this method served as a methodological triangulation, using more than one method to gather data, increasing the validity and accuracy of results (L. Cohen, Manion, & Morrison, 2007)

4.7 Summary of Results

This chapter presented the results and analysis of this investigation of information problem categorization during the Task Definition stage of the information problem-solving process. Four sets of data were collected:

- 1) Performance scores (categorical determinations) of experts and novices on tasks related to the domain of librarianship
- 2) Performance scores of experts and novices on tasks related to the domains of everyday life situations and statistics
- 3) Personal constructs recorded via the RepGrid Technique during sorting tasks related to all three domains
- 4) Demographic information

Analyses of these data sets reveal insights into the nature and impact of Task Definition within the information problem-solving process. In sum, the results reveal that trained and experienced librarians demonstrate the same thinking processes within their domain as the experts in several other domains as described in cognate fields of research. Novices within the domain of librarianship do not demonstrate these thinking processes. The narrative aspects of information problems do have a significant impact on the categorical determinations of both librarians as experts and novices. Moreover, this expert thinking transfers to the other domains under study in this research.

5.0 Chapter 5: Discussion and Implications

In this chapter, the research questions are reviewed in section 5.1, and findings revealed by the results are discussed in section 5.2. This discussion focuses first on the nature and impact of Task

Definition within the expert domain, section 5.2.1, and then on the nature and impact of Task Definition within novel domains, where the issue of transfer is addressed in section 5.2.2. The emergence of a model for intervention that incorporates several research findings, the Information Problem-Based Learning Environment, is described in section 5.3. The chapter is summarized in section 5.4

5.1 Introduction

This research investigated the nature and impact of Task Definition. The data collected and analyzed in Chapter 4 reveal insights into the nature of thinking processes during the Task Definition stage of the information problem-solving process. The data also reveal insights into the impact of these thinking processes on subsequent success in solving information problems.

The Big6 model of the information problem-solving process recognizes two components of Task Definition: 1) definition of the information problem and 2) identification of the information needed to solve the problem. Library and information science scholars have focused on the second component in their study of information needs, but little work has been done in the field with a focus on the first. This research was designed to shine a light directly on this component of Task Definition. There are inherent challenges in empirical research on cognitive processes, which cannot easily be observed and measured. The research design managed these challenges through the application of appropriate methods and system of data analysis.

The triad judgment task is a method used in the field of cognitive science to measure the cognitive process of problem categorization. In this research, the method is applied to the measurement of categorical determinations typically made at the initial stage of the information problem-solving process, Task Definition. This method reveals the nature of thinking involved

when a problem-solver encounters an information problem. It also investigated the impact of this thinking; that is, how do categorical determinations made at this stage affect success in information problem-solving? In this chapter, the results reported in Chapter 4 as they relate to the research questions are discussed.

Essentially, this research seeks to answer the questions:

- 1) Who are information problem-solving experts?
- 2) How do they think?
- 3) Is expert information problem-solving thinking transferable?

The research questions emerging from the problem space described in Chapter 1 answer these questions:

Overarching Research Question: What is the nature and impact of Task Definition in terms of information problem categorization within the information problem-solving process?

1. How do experts and novices in the domain of librarianship categorize domain-related information problems?

1.1. Specifically, how does the recognition and use of surface or deeper structural features in information problem categorization vary as a function of experience within the domain of librarianship?

1.2. How does the categorization by experts in the domain of librarianship compare to categorization by experts in other domains?

2. How do experts and novices in the domain of librarianship categorize information problems in domains other than librarianship?

- 2.1. Specifically, does expertise in the domain of librarianship result in the recognition and use of surface or deeper structural features in information problem categorization in novel domains?
- 2.2. Why does the categorization by experts in the domain of librarianship transfer or fail to transfer to other domains?

Following this discussion are implications for the field of library and information science.

5.2 Discussion and Implications

Research Question 1.0 (RQ 1.0) and related results will be discussed in section 5.2.1, and Research Question 2.0 (RQ 2.0) and related results will be discussed in section 5.2.2. These discussions will yield an answer to the overarching research question:

What is the nature and impact of Task Definition in terms of information problem categorization within the information problem-solving process?

5.2.1 The Nature and Impact of Task Definition Within a Domain of Expertise

As described in the literatures of library and information science (Head & Eisenberg, 2008), cognitive science (Hardiman et al., 1989), and the learning sciences (Bransford et al., 2000), the initial stage of the problem-solving process is crucial in the definition of the problem situation and subsequent application of successful solution strategies. This stage is termed Task Definition in The Big6 model of the information problem-solving process. The extensive literature on information needs addresses the component of Task Definition in which the problem-solver identifies the information needed to solve the problem; however, the other component in which the problem-solver defines, or categorizes, the information problem has received scant attention.

This research addresses the gap in the literature by answering Research Question 1.0 (RQ 1.0):

RQ 1.0: How do experts and novices in the domain of librarianship categorize domain-related information problems?

This question aims to reveal the nature and impact of Task Definition as demonstrated by experts and novices in the domain of librarianship during the task of categorizing information problems.

To investigate the nature and impact of Task Definition within the information problem-solving process, the first component focused on categorical determinations by experts and novices within the domain of expertise: librarianship. Information problem scenarios employed in this stage of the investigation were situated within a context that would be familiar to a graduate of an accredited master's degree in library and information science program with even a basic level of experience.

A review of the core course descriptions in the master's program at the University of Washington reveals that the phrases "information behavior," "information literacy," and "determination and analysis of information needs" are key concepts. In mastering these concepts, students develop competencies in assessing the type of needs presented by library users. These types of needs include 1) determining the nature and extent of information needed, 2) locating and accessing needed information, and 3) the critical evaluation of the source of information. With the training and practice that comes with librarianship, these types of needs will be readily recognizable in a variety of contexts.

To ensure that the information problem scenarios were representative of situations that would draw upon librarianship expertise, a systematic and structured formula was applied to the generation of information problem scenarios. The formula held constant the perceived complexity to a Normal Information Processing Task (Bystrom & Jarvelin, 1995); in other

words, in this type of task, the information problem-solver will have a clear picture of the goal state, but may experience uncertainty about the information that will be needed and the solution strategies that may need to be implemented. The scenario formula also held constant the type of problem as described by Jonassen (2000) to a Decision-Making Problem.

The formula included three levels of information (Bystrom & Jarvelin, 1995): 1) domain information related to librarianship; 2) problem information, which relates to the context of the information problem in each domain, and served as the surface features, or narrative of the information problem scenarios; and 3) problem-solving information, which relates to strategies for problem treatment, and served as the deeper structural features of the information problem scenarios. The three types of need described above served as the problem-solving information.

The literature in information problem-solving delineates characteristics of the problem and of the problem-solver (Bystrom & Jarvelin, 1995; Jonassen, 2010). By holding constant characteristics of the problems as described above, the investigation focused on the characteristics of the problem-solver.

To answer this question with specificity, the first sub-question asked:

1.1 Specifically, how does the recognition and use of surface or deeper structural features in information problem categorization vary as a function of experience within the domain of librarianship?

Results of data analysis reveal that training and experience in the domain of librarianship promotes expert thinking in the categorization of information problems that are related to the domain of librarianship. This expert thinking involves recognition of the underlying principle in the problem scenario, or deeper structural feature. This is the way that experts think in the

research of cognate literatures, and now describes the way that experts in the domain of librarianship, librarians, categorize domain-related information problems.

Professional Preparatory Programs

Regardless of comparison type, librarians categorize information problems differently than those without such training and experience. Like experts in other domains, librarians categorize information problems based on underlying principles; also like experts in other domains, their categorizations lead to the application of more effective solution strategies to problem situations.

Results of data analysis reveal the first finding:

- Training and experience in librarianship produces predictable expert behavior in information problem-solving.

The core content of professional training programs for librarianship addresses the skills needed in professional practice as determined by accreditation bodies, such as the Council for the Accreditation of Educator Preparation (CAEP) and the American Library Association (ALA). An accredited program will require coursework designed to develop competencies in several areas related to the practice of librarianship, including organization and management of knowledge and information systems, instruction and leadership in information environments, and the delivery of information services. Clearly, there is a broad type of expertise to be developed in such a course of training, yet some may argue that this expertise has not yet been clearly defined. This research proposes that this broad expertise is in the solving of problems which require the access, evaluation, and use of information; that is, information problem-solving.

This finding states that expertise in information problem-solving may be achieved through training and experience. In other words, completion of a program that focuses on the development of skills related to effective information problem-solving will result in this type of expert thinking. It should follow that non-librarians could learn to think like librarians and demonstrate expert thinking in information problem-solving as well. This is the mission of school library programs in Washington State, and others across the country, “to ensure that students...are effective users of ideas and information” (ALA, 1998, p. 6). The challenge, of course, is to determine the components of such a program—short of completing a master’s degree program in library and information science (MLIS) and working in the field. The greater challenge is to determine the most effective method for getting everyone to think like a librarian.

Other Factors

This research was designed to compare the Task Definition behaviors of two different sample groups—those with librarianship training and experience, and those without. This research was not designed to determine the roles of age and education level in the demonstration of expert thinking, but this line of inquiry is an obvious extension. The personal constructs of those participants in the exploratory sample group do not suggest that their categorical determinations were significantly different than those of the novice group, but these results are far from conclusive. This finding resolves this issue for the time being by revealing the impact of expert thinking, thinking that may be developed at any age and level of education with an effective program.

Why is it insufficient to propose that age plays a significant role in categorical determinations? Because it is unacceptable to conclude that information problem-solving expertise can only be

achieved later in life—the goals of librarianship training programs are to develop that expertise at any age—in effect, accelerate progress toward expertise. What aspects of pedagogy of librarianship can be implemented in K-12, academic, and work training to develop information problem-solving skills? If we accept that expertise in any field just takes 10,000 hours with focused practice and training (Ericsson et al, 1993), are we accepting that young adults are not expected to be proficient in solving their own info problems? How can we compress that time frame to become expert information problem-solvers?

Development of Interventions to Improve Skills.

This research proposes that a program or method that develops expertise in information problem-solving, and is anything short of completion of an accredited MLIS program, be termed an intervention. An intervention may be short-term, or targeted; these would include a learning activity, a training seminar, a web tutorial, a classroom lecture, and the like. A longer-term, or sustained, intervention would include a series of targeted interventions that are structured in a comprehensive curriculum or training program.

- Targeted and sustained interventions focused on Task Definition may promote expert information problem-solving.

This proposal, the Information Problem-Based Learning Environment (IPBLE), will be described in section 5.3.

The Nature of Information Problem-Solving Expertise

That librarians categorized information problems based on the underlying principles of topic definition, information location, or information evaluation, reveals the proficiency in Task

Definition that is the result of training and experience in librarianship. Moreover, that Task Definition proficiency leads to information problem-solving success through the application of effective solution strategies. The data reveals:

- Librarians recognize the underlying information needs with information problems.

An extension of this finding suggests that the principles of Task Definition are appropriately applied to the design of information systems, addressed later in the section.

It must be noted that this research confirms findings in other expertise studies of the effect of surface feature similarities in categorical determinations. Even experts will make determinations based on surface feature similarity; under certain conditions, this an effective strategy (Bassok, 1996).

- Surface feature similarities do affect categorical determinations made by experts and novices.

Metacognition

The data collected during the application of the RepGrid technique in Phase 2 suggests that metacognition plays a role in Task Definition. Participants in all sample groups typically verbalized constructs that matched the strategy applied to grouping tasks. In other words, participants were often aware of using a grouping strategy that focused on either surface or deeper structural feature similarity. Although this metacognition was typically applied, it was not always applied appropriately, as described by the Grouping Strategy Profiles.

- Metacognition plays a role in categorical determinations during Task Definition.

Information Problems

The literature on the nature of information problems concludes that they are not well-structured. Studies on the categorical determinations of experts employed well-structured problems. This research employed problems that could not be resolved without the access, evaluation, or use of information not included in the problem text. The first finding determined that librarians demonstrate expert thinking, the same type of thinking that experts in other domains as chronicled in numerous studies. This thinking was applied to the information problems employed in this research, suggesting the next finding:

- Information problems are ill-structured, but categorized during Task Definition.

This finding reveals that even problems that are not well-structured are categorized during Task Definition in similar ways to well-structured problems. Moreover, information problems will have underlying principles related to stages of the information problem-solving process. There are three dimensions to every information problem (Bystrom & Jarvelin, 1995): 1) domain information; 2) problem information, which relates to the context of the information problem in each domain; and 3) problem-solving information, which relates to strategies for problem treatment. The data supports this description. What remains to be examined is the degree of similarity in the cognitive processes involved in well-structured problem categorization and information problem categorization.

The second sub-question, Research Question 1.2 (RQ 1.2) states:

RQ 1.2 How does the categorization by experts in the domain of librarianship compare to categorization by experts in other domains?

Results of data analysis reveals that librarians categorize information problems according to the underlying principle related to the information problem-solving process, whereas non-librarians categorize according to narrative features, which may result in an ineffective solution strategy. Even when librarians were compared to categorical determinations made purely by chance, they made determinations based on deeper structural features significantly more frequently. This expert thinking appears to be consistent and durable.

Librarians as Experts in Information Problem-Solving

This data reveals that this information behavior is predictable, further supporting library and information science as a social science. Moreover, it suggests application of research from cognate fields to better understand information behavior:

- The expertise of librarians may be described by the vast body of literature on expertise.

The results also reveal that narrative features of information problems, or surface features, play a significant role in the categorical determinations of both experts and novices. Without the distraction of any surface feature similarity, all problem-solvers will tend to look for and recognize problem similarity according to underlying principle, although librarians will categorize accordingly more frequently than novices, who may see no similarity at all and categorize at random. These patterns mirror those described by the expertise literature in cognate fields.

Why aren't expert scores higher for expert domain of librarianship? Even the experts do not always make categorical determinations based on the deeper structural features of problems, however. Studies of problem representation in cognitive science reveal the complex role that

narrative features of problems play in effective categorical determinations. In certain domains, narrative features are related to the problem type, and categorization according to these features is appropriate. However, this research was designed with a straightforward interpretation of expertise theory.

It is interesting to note that without the distraction of a narrative feature similarity, non-librarians will make categorical determinations based on underlying principles more frequently; in fact, these determinations increase more dramatically than those of librarians in these situations.

Perhaps the shift from non-expert to expert thinking may be nudged more easily than anticipated, suggesting the promising impact of interventions.

This research provides a more accurate and comprehensive description of the nature and impact of categorization in Task Definition during the information problem-solving process than was currently available, and informs our current understanding of information literacy. Theories from the cognitive sciences and the learning sciences are appropriate to apply to an investigation of information problem-solving; specifically, structure-mapping theory, analogical reasoning, and Cognitive Load Theory.

This finding prompts a review of the profile of expertise, but with the added layer of librarianship (Bransford et al., 2000). Of course, the term “librarian” in this modified profile refers to those trained and experienced in the field:

- **Patterns of Information.** Librarians recognize underlying features and meaningful patterns of information, and recognize deeper structures of information problems which delineate the problem-solver’s actual need, as described by theories of analogical reasoning and structure-mapping (Bassok, 2003; Gentner, 1983).

- **Knowledge Organization.** Librarians' content knowledge is organized in ways that reflect a deep understanding of their content domain; it is organized around core concepts that guide their thinking; essentially, librarians' knowledge is "cross-referenced"—linked together by associations.
- **Conditionalized Knowledge.** Librarians' knowledge is conditionalized on a set of contextualized circumstances; that is, librarians may engage only a relevant subset of their vast store of domain knowledge for a particular problem; the effects of minimal impact on working memory provide a benefit to librarians, as described by Cognitive Load Theory (Merriënboer & Sweller, 2005).
- **Knowledge Retrieval Fluency.** Librarians retrieve knowledge easily; the processes involved in the recall of relevant information nears automatic. However, because librarians attempt to understand information problems before executing a solution strategy, they may not necessarily be faster than novices at solving information problems, but likely more successful.
- **Effective Strategies.** Librarians tend to use a working-forward strategy; that is, working from the current state to the goal state; novices, on the other hand, will often resort to a working-backward strategy, seeking to adjust the goal state to make it more like the current state. Librarians recognize the type of information problem they are dealing with and the type of appropriate solution within their domain. Thus, librarians know they will be successful from the start--supporting the proposition that Task Definition is crucial to successful information problem-solving.
- **Teaching and Transfer.** Librarians may not be consistent in their ability to convey their knowledge to others, and to transfer their skills to novel situations and domains.

Descriptions of information literacy imply that related skills are domain-general, and results of data analysis reveals evidence of transfer, but further research is necessary.

Studies on domain expertise focused attention on a conceptualization of problem representation, or Task Definition, which included an embedded solution strategy. Since these characteristics are brought to bear upon problem-solving situations, and distinguish experts from novices within a given domain, this research serves as a rich resource in understanding parallel processes within information problem-solving. These studies suggest that the problem representations of experts are more sophisticated than those of novices due to more complex and robust schemas for problem situations in a domain. Thus, expert problem representation is likely to lead to successful solution generation, just as skilled Task Definition is likely to lead to successful solution strategies in the information problem-solving process.

This is an exciting development in the study of information literacy, made even more intriguing by the proposition that the field of library and information science is a meta-science (Bates, 1999). This development is the topic of section 5.3.

Methods for Examining Expertise

This finding also reveals that the method employed in this research, the triad judgment task, is validated as an appropriate approach to examining Task Definition, and suggests another finding:

- The triad judgment task expands the repertoire of methods applied to information behavior research.

As described by the Big6 information literacy approach, Task Definition is composed of two sub-stages; in the first sub-stage, the problem is identified, and in the second, the information

needed to solve the problem is identified. The body of knowledge that has initiated an investigation of Task Definition within the field is the study of information needs. Scholars within the field have made significant contributions to our understanding of information needs; namely, Taylor's levels of need (1968), Dervin's Sense-making (1992), and the anomalous state of knowledge (ASK) approach by Belkin, Oddy & Brooks (1982). These and other scholars have developed theories and conceptual frameworks for understanding information needs, but typically these efforts emphasize information seeking, search, and the design of information retrieval systems. The recognition and assessment of an information need are largely cognitive processes, and methods designed to examine cognition have yet to be employed consistently within the field of library and information science.

The method employed in this research, the triad judgment task, was appropriate for examining the research questions in this study. This method enabled the researcher to focus on the cognitive processes related to Task Definition. Previous studies employing this method have revealed significant differences in ways that experts and novices categorize problems within a content domain (Dufresne et al., 1992; Hardiman et al., 1989; Hogan & Rabinowitz, 2009; Quilici & Mayer, 1996, 2002; Rabinowitz & Hogan, 2008). These studies constructed task problems that varied according to surface or deeper structural features related to a particular domain of knowledge. As studies conducted outside the field of library and information science, they were not concerned with the information that participants perceived as necessary to solve the task problems, however. This method is well-established and well-suited to an examination of Task Definition; more specifically, the categorization of information problems based upon surface or deeper structural features during Task Definition within the process of information problem-solving.

In future applications of this method, some modifications are suggested. For this research, useful comparisons could have been S-D, N-D, and S-SD; in this way, analysis could be conducted on comparison types with a look at whether surface features distract expert focus on deep structures. In this research, the N-S comparison type was used rather than the S-SD; the N-S comparison type served to determine if S will be chosen in the absence of D, and to disrupt any pattern recognition on the part of participants. It is also suggested that the domain of physics may produce more appropriate responses from participants as described in the research design rationale; in this research, many participants expressed some familiarity with statistics principles.

Implications for Information Systems

Results of this research corroborate those of expertise studies in cognate fields. These studies reveal the nature of expertise in a variety of domains, and identify problem representation in the problem-solving process as a crucial difference between domain experts and novices (Chi et al., 1989). This research finds that there is a direct correspondence with expertise in information problem-solving, and Task Definition as a crucial difference between expert and novice information problem-solvers. With a focus on this initial stage of the information problem-solving process, how can information systems facilitate expertise for all information problem-solvers?

- A design shift in information systems toward Task Definition will facilitate expert information problem-solving.

This finding provides a direction for information systems that apply the principles of Task Definition. LIS scholars have provided insight into effective intermediation based on the determination of the information need. Taylor (1962, 1968) developed a conception of

information needs experienced by the user of library and information systems. Taylor's focus was the negotiation of a question posed to an information system, either through a reference librarian as a human intermediary, or directly to an information system in a self-help situation, and his goal was to inform the discipline of information search. Best practices in conducting the reference interview include the two components of Task Definition: defining the task and identifying the information needed (Ross, 2009). Unfortunately, many college students do not seek assistance from reference librarians (Head, 2008) and when they do, these practices are not always applied during the reference interview (Sanders, 2016).

Library and information science scholars have described the components of information systems that are effective in determining user needs (Belkin & Vickery, 1985), and smart systems and decision support systems are used in a number of fields of practice. One example is TurboTax, tax preparation software, which walks the user through a decision tree, providing info along the way. Decision-making, however, is only a subset of problem-solving. When the typical information problem-solver turns to a web search for help, they are not likely to find assistance in solving the problem. Web search systems are currently designed for The Big6 stage of Location and Access, in the middle of the information problem-solving process. This finding challenges information system designers to assist in the solution of problems, rather than simply generate a list of search results.

Perhaps the evolution in web search is a progression from a collection of information artifacts to a repertoire of learning resources. For example, a query on Google or Bing seeking information on tying a tie or learning about a statistical analysis will yield results linked to an instructional video. Implicit in these queries is the question of "how do I...?" versus "what is...?" At this

point in time, the information artifacts curated in these searches provide more assistance in solving information problems than the system itself.

The next section discusses the results related to the nature and impact of Task Definition in domains other than librarianship, and addresses the issue of transfer.

5.2.2 The Nature and Impact of Task Definition in Novel Domains

Another important aspect in understanding information literacy is the proposition that skills may be applied across domains. The transfer of information literacy skills to novel problems and domains is assumed in much of the pedagogy of library and information science, but remains untested. Although studies conducted by Project Information Literacy find similarities, seemingly in support of the domain-general approach, they also uncover differences between information behaviors in course-related research and everyday life contexts (Head & Eisenberg, 2009a, 2009b, 2010b), seeming to call such an approach into question. Lloyd found evidence of domain-specific information literacy skills in a variety of contexts (Lloyd, 2005, 2007b, 2009; Lloyd & Williamson, 2008), but does not explicitly rule out the possibility of certain skills as domain-general.

The cognitive sciences and the learning sciences host similar longstanding debates. Smith (1991), in proposing a unified theory of problem-solving, recognizes the role of domain-specific knowledge in successful problem-solving, but also identifies general problem-solving knowledge as an important factor. However, research in the cognitive sciences reveals that domain experts are not consistent in their ability to transfer their skills to novel situations and domains (Bernardo, 2001; Didierjean, 2003; Hatano & Oura, 2003; Inagaki, 1986; Mayer, 1998; Mayer & Wittrock, 1996; Novick & Hmelo, 1994). Mayer & Wittrock (1996) characterize the research on

the transfer of problem-solving skills as disappointing for this simple reason: “Problem-solving transfer seems to be rare” (p. 51). While research in the cognitive sciences makes it clear that the domain-specific background knowledge of domain experts is important (Chi, 2006; Bransford, Browning & Cocking, 2000), it is unclear the degree to which domain-general process skills knowledge may play a role in the successful problem-solving skill of experts (Rabinowitz & Hogan, 2008; Smith, 1991). Research Question 2.0 (RQ 2.0) emerged from this issue:

RQ 2.0 How do experts and novices in the domain of librarianship categorize information problems in domains other than librarianship?

Some have argued that the field of library and information science is a meta-science, oriented toward the representation and organization of information within every domain rather than knowing the domain information (Bates, 1999; Pettigrew et al., 2001). Perhaps, for experts in information problem-solving, a greater proportion of their domain knowledge may be characterized as domain-general when compared to that of experts in other content-oriented domains such as mathematics, physics, and chess. The uncertainty over the domain-generality of information literacy skills remains as a gap in the literature; sub-question RQ 2.1 targets this gap:

RQ 2.1 Specifically, does expertise in the domain of librarianship result in the recognition and use of surface or deeper structural features in information problem categorization in novel domains?

Results of data analysis reveal that training and experience in the domain of librarianship promotes expert thinking in the categorization of information problems in certain domains other than librarianship. This expert thinking involves recognition of the underlying principle in the problem scenario, or deeper structural feature.

The issue of transfer remains unresolved in the cognate literature. However, the data does reveal transfer to the two non-expertise domains examined in this research: everyday life situations and statistics. The information problems in each of these domains presented different challenges to participants in the study. The domain of librarianship served as the focus of the research to compare expert and novice differences; it was expected that trained and experienced librarians would recognize the underlying principles of these scenarios related to stages of the information problem-solving process, and categorize accordingly. The domain of everyday life situations provided information problems that were expected to be familiar to both sample groups, and categorizations based on underlying principles was expected of all participants. The third domain of statistics provided the opposite challenge, in that it was expected that few participants would recognize the underlying principles and categorize accordingly; the expected results were categorizations based on narrative features of the scenarios, or random selection.

Librarian Thinking

Categorical determinations based on underlying principles were significantly different for all participants across the three domains; that is, for all participants, categorization based on underlying principles increased significantly from statistics to librarianship to everyday life situations. However, within each of the three domains, librarians were significantly more likely to make categorical determinations based on underlying principles. Like experts in other domains, librarians categorized information problems based on underlying principles; also like experts in other domains, their categorizations lead to the application of more effective solution strategies to problem situations. Results of data analysis reveal the finding:

- There is value in thinking like a librarian in multiple domains.

While this expertise is demonstrated in ways like those demonstrated in other domains, librarianship is not a typical domain. This finding may support the proposition of library and information science as a meta-science. Evidence also includes the example of many institutions of higher learning combining library and information science programs with those of other disciplines to offer interdisciplinary graduate degrees. This perspective has been applied in a similar fashion to the pedagogy of teaching described by Shulman (L. Shulman, 1986), and an interesting comparison between the two disciplines may be made.

This finding reveals the layers of analysis necessary for effective information problem-solving in a variety of domains. The earlier finding related to the nature and structure of an information problem referenced the description of the three dimensions of every information problem: 1) *domain information*; 2) *problem information*, which relates to the context of the information problem in each domain; and 3) *problem-solving information*, which relates to general strategies for problem treatment (Bystrom & Jarvelin, 1995).

It is the third dimension, problem-solving information, that likely holds the key to understanding the “value in thinking like a librarian in multiple domains.” This problem-solving information, revealed in this research as expertise in information problem-solving, is likely the layer of analysis necessary for effective information problem-solving in a variety of domains. When applied to a content domain new to the learner, this layer promotes a different kind of thinking. For example, rather than simply learning the content of history, librarian thinking encourages the learner to “think like a historian” (Wineburg, 1991), or a mathematician, or economist, and so on (Jonassen, 2010). By applying this as an instructional strategy, students are encouraged to think like an expert in all subjects; that is, experts ask, “What KIND of a problem is this?” and then apply a solution strategies effective for that type of problem.

This finding prompts the need to investigate the nature and impact of the second dimension, problem information—information that is specific to the type of problem situated within its domain. Lloyd found evidence of domain-specific information literacy skills in a variety of contexts (Lloyd, 2005, 2007b, 2009; Lloyd & Williamson, 2008), and describes another definition of information literacy: “The second definition of information literacy, which has been used more recently, tends to emphasize the learning experience created when an individual engages and uses information.” (Lloyd, 2010, p. 41). These concepts are applied in a sustained intervention described in section 5.3.

The second sub-question examined the reasons why expert thinking may or may not transfer:

2.2 Why does the categorization by experts in the domain of librarianship transfer or fail to transfer to other domains?

The appropriate data set to examine for an answer to RQ 2.2 is the data collected from the RepGrid Technique. This data is inconclusive, however, in determining an answer. What is clear from related findings is that information problem-solving expertise is complex. This research puts a focus on the components of information problem-solving knowledge, and which are likely to be accessible and applicable to new information problem situations in new domains. What can be concluded from the examination prompted by this research question is:

- Information problem-solving expertise is comprised of multiple components.

The discussion above described the components of information problems as described by Bystrom & Jarvelin (1995): 1) *domain information*; 2) *problem information*, which relates to the context of the information problem in each domain; and 3) *problem-solving information*, which relates to general strategies for problem treatment. This research contributes to the body of

literature on transfer by suggesting that certain dimensions of information problem-solving expertise are more likely to transfer than others. The data from the RepGrid Technique revealed that participants frequently transferred all three dimensions of their expertise to information problems within their domain of expertise; however, in the unfamiliar domain of statistics, they frequently transferred only the dimension of problem-solving information. Further study on the transfer of information problem-solving expertise through this lens is in order.

This finding suggest modifications to the pedagogy of information literacy; that is, expert information problem-solving. These modifications in turn have implications for library services and professional preparatory programs. These issues are addressed in section 5.3.

5.3 The Information Problem-Solving Learning Environment

Results of this research provide the principles for a learning environment that promotes expert information problem-solving. This sustained intervention is based on the concept of the Problem-Based Learning Environment (PBLE) developed by David Jonassen (2010) and modified by the integration of The Big6 model of information problem-solving by Eisenberg & Berkowitz (1988).

The foundation of the PBLE is case-based learning: “different kinds of problems and the support needed to learn to solve them are represented as cases” (Jonassen, 2010, p. 149) This approach is supported by the theoretical framework developed for this research; that is, the construction of knowledge through experience with information problems, and the application of analogical thinking in the Task Definition stage of the information problem-solving process.

Domain experts categorize problems according to type through analogical reasoning, and these types are described by the concept of schema (Novick & Bassok, 2005). Within problem schema

is embedded a solution strategy for successful solution to the problem (McNamara, 1994; Novick, 1988). One of the factors that distinguish experts from novices is that experts categorize problems according to underlying structural elements of the problem, whereas novices tend to categorize based upon surface elements of the problem (Chi et al., 1981; Schoenfeld & Herrmann, 1982). The advantage of problem categorization based upon structural features versus surface features is that it enables the matching of successful solution strategies (Novick & Bassok, 2005). As problem-solving experience increases, so too does the reliance on deeper structural features in problem categorization (Niegemann & Paar, 1986). Bransford, Browning & Cocking (2000) recognize the importance of the initial stage of problem representation: “An important aspect of learning is to become fluent at recognizing problem types in particular domains...so that appropriate solutions can be easily retrieved from memory” (p. 44). The PBLE is centered on theories describing the induction of schema.

In addition to straightforward strategies for promoting analogical reasoning—highlighting deeper structures of problem situations and pointing out parallels in object and relational attributes between base and novel situations—other strategies have been determined. In a follow-up study, Gick & Holyoak (1983) found that two or more direct analogies, with essentially similar deeper structures, may be significantly more effective than one. One analogous story may not be enough to call attention to the underlying structure, and a second may do just that; an analogous story that is only partially similar, or only superficially similar, will not produce this effect (Gick & Holyoak, 1980). Moreover, Needham & Begg (1991) found that problem-oriented training is more effective than memory-oriented training--when subjects were told to memorize as many practice problems as they could, their skills did not transfer as well as those told to understand the underlying structure of the practice problems so that they could explain them to someone

else. Cummins (1992) had one participant group compare example algebra problems and another simply read them; she found that this type of analogical comparison was an important component in the induction of problem categories.

What distinguishes the PBLE from other forms of problem-based learning is the recognition of two distinct components of cases: the form of cases, and the function of cases (Jonassen, 2010, p. 150). In the Information Problem-Based Learning Environment (IPBLE), information problems serve as the building blocks of knowledge, as schema for types of problems and expert thinking are developed. The form of information problems as cases may include: problems to be solved, worked examples, case studies, analogies, prior experiences, alternative perspectives, and simulations. The function of each information problem case will depend on the needs of the learner or the context in which information problem-solving skills will be applied.

With the addition of the information dimension, this approach holds potential for school library programs to make transformational change in the development of expert IPS thinking.

5.3.1 A Model of IPBLE for the P-20 Library Program

The results of this research do suggest “a boost” from training and experience in librarianship in thinking like an expert in the categorical determinations of information problems in the domains under study. The conditions in which these determinations were made warrant further research; thus, the debate over the generalizability of information problem-solving skills has not been resolved by this research. However, there is enough evidence to proceed with a model for a learning environment that develops information problem-solving skills based on the principles of expert thinking revealed by this research.

The problem-solving learning environment (PSLE), developed by Jonassen (2010), is founded on similar principles. In these environments, problems serve as the building blocks of knowledge. These problems are termed “cases” and may be organized by form and function. The conceptual and operational frameworks of a model that builds on Jonassen’s PSLE are described below.

Conceptual Framework of the IPBLE

The epistemological basis for the Information Problem-Based Learning Environment (IPBLE) is a conception of educational constructivism as developed by Kuhlthau (2004). In her development of the information search process, Kuhlthau borrowed the concept of constructivism and applied it to her investigation of how knowledge is constructed during information seeking and search. When students face uncertainty, she proposes, they move to actively construct an understanding of the world. Kuhlthau’s interpretation of constructivism begins with the learning theory of John Dewey. According to Dewey (1910), learning is an active and individual process, and is reinforced through reflection. It is through reflection that we recognize the causality between our actions and their consequences. Reflective thinking is important in successful information problem-solving, and is compatible with constructivist learning environments. As we build a more complete and accurate understanding of the world around us, we are able to transfer this understanding from one situation to another. Kuhlthau highlights Dewey’s emphasis on education’s key role in a democratic society; she notes the connection to conceptualizations of information literacy that emphasize the need to accommodate change through learning: “Learning how to learn may be understood as individually internalizing a constructivist approach to learning” (Kuhlthau, 2004, p. 15).

Vygotsky’s descriptions of the social conditions under which optimal learning occurs (Kozulin,

2003) informs her work as well in the design of instructional programs and the delivery of information services, thus giving her approach an added dimension: social influences upon the construction of knowledge.

Kuhlthau adds to Dewey's philosophical approach to knowledge construction the perspective of Kelly, who offers a psychological dimension to constructivist theory. Kelly's Personal Construct Theory (1963) proposes that experiences generate constructs which organize perceptions into patterns and enable predictions about the way the world works. This system of constructs is highly personal and guides behavior based upon predictions; the restructuring of constructs to assimilate familiar information and the formulation of new constructs to accommodate new information constitutes learning that occurs throughout life. Prediction is a key concept in Kelly's theory—we make choices in our behavior that reflects our predictions about an outcome. These outcomes will either confirm or disprove our predictions, but either will provide feedback that will alter our constructs and inform future choices. This approach is compatible with an approach to understanding schema, which is a framework of constructs; schemas are continually reformulated with the experience of each new problem situation. Moreover, knowledge is a framework of highly-developed, that is, robust, schemas. One study found that a learner's epistemological beliefs about learning has an impact on learning success; in fact, the constructivist belief was found to contribute to the most effective learning (Tu, Shih, & Tsai, 2008). Constructivist theory, as interpreted by Kuhlthau, serves well this investigation of information literacy. Talja, Touminen & Savolainen (2005) concur: "Instead, humans must "construct" their own knowledge. Individuals build their knowledge through their experiences that enable them to build "mental models" of the world. Mental models consist of schemas,

scripts and knowledge structures. These models may change and become more detailed and sophisticated as individuals receive new sensory data or encounter novel situations” (p. 83).

Within this framework is woven Jonassen’s (2010) approach to analogical reasoning; two or more cases, with the appropriate instructional support needed to resolve these cases, serve as the building blocks for schema induction. As applied to the study of problem-solving, analogical reasoning relates what is known about a current problem situation to another in memory established through prior experience. The assumption is that when there are meaningful parallels between two situations, there will likely be more information that can be inferred, according to structure-mapping theory (Gentner, 1983). In the initial phase of problem-solving, a person will perceive the apparent components of the problem; in cognitive terms, the elements, their properties, relationships between elements, and constraints. In situational terms, the problem type, the problem-solver’s induced schema, its situatedness within a social, physical, and temporal context. People will experience this process in varying degrees according to declarative and procedural knowledge of these factors; typically, experts will recall representations of the problematic situation that are more robust and reflect the underlying structure.

Holyoak (1984) has described how analogical thinking is involved in all problem-solving in his development of a theory of analogical thinking. In essence: “The schema is the abstract category of which the specific analogs are the instances” (Holyoak, 1984, p. 208). Holyoak goes further to define the process of schema induction: “In essence, the process of abstracting a schema by eliminative induction involves deleting differences between the analogs while preserving their commonalities” (p. 208). As an example, the two stories used in the study may be reduced to “rays destroy tumor” (target analog, since it is the problem to be solved) and “army captures fortress” (base analog, since it must be recalled from memory); the schema would be “overcome

(force, target).” Thus, the surface features of the target analog must be ignored for the mapping between “rays destroy tumor,” which resides within the schema “overcome” and “army captures fortress” to occur. Finally: “An explicit problem schema will make salient those causal aspects of a situation that should trigger a particular plan of action” (Holyoak, 1984, p. 213). Thus, a robust and explicit schema will identify a course of action, or the generation of a suitable solution.

Structure-mapping theory (Gentner, 1983; Gentner, Loewenstein, & Thompson, 2003) describes the cognitive process of structural alignment, in which setting up of correspondences between structured representational elements in two different domains or situations allow for the transfer of information guided by a common relational structure (Jonassen 2011, p. 260), allowing for analogical reasoning (Bassok, 2003). Structure-mapping theory is useful in understanding several findings from the cognitive sciences related to analogical reasoning. Jonassen states that the cognitive processes necessary for each and every kind of problem-solving situation are analogical reasoning and causal reasoning (2011, p. 362). It is unknown whether these skills are sufficient for learning to solve problems (others may be needed in addition), but they are necessary in every situation. While analogical reasoning is necessary for the induction of robust problem schemas, causal reasoning is necessary to recognize the causal relationships between problem elements and stimulate solution generation through a process of inference and prediction. Through analogical reasoning, unknown solutions may be derived from those that are already known (Reisberg, 2006, p. 483). Concepts that may at first seem confusing may be made clear by means of analogical reasoning; for example, comparing electricity to water flow, molecules to the solar system, the functioning of the heart to a pump, and the like.

Finally, the approach to each case within this framework is based on the Big6 model of information problem-solving. The Big6 Skills approach to information problem-solving by

Eisenberg & Berkowitz (1988) describes the process of successfully solving an information problem. This model describes the first stage as Task Definition, in which the problem solver defines the task or problem to be solved, and then identifies the information needed to solve the problem. From there, the problem solver engages in information seeking strategies, location and access, use of information, synthesis, and evaluation. The process is often not linear, and stages may be repeated throughout the process.

However, the application of the Big6 within the IPBLE is dependent upon the social and situational context of each case. This application draws upon a socio-cultural approach to information literacy as described by Lloyd (2014). As reviewed in Chapter 2, approaches to information literacy vary. Lloyd (2010) proposes a socio-cultural approach, that information literacy is situated within a contextual environment, with a unique set of information sources, channels, and formats, and is realized through the engagement of social constructs, sensory, and cognitive factors. While emerging from an educational constructivist epistemology, with cases serving as the learning experience building blocks leading to knowledge, the IPSLE may support an alternative approach such as the one proposed by Lloyd by employing an adaptive component. According to Lloyd's approach to information literacy as a socio-cultural practice, a domain novice will learn to act as a practitioner through a formalized training program, but "they cannot become practitioners because they are removed from the reflexive and reflective embodied experiences and tensions arising from practice" (Lloyd, 2014, p. 92). To become fully expert in information literacy within a domain, it is necessary to become immersed in practice.

Lloyd recognizes the role that public library programs may play in the development of information literacy skills. In her review of a study by Harding (2008), she highlights the opportunities this role provides, including widespread recognition of the public library as a

center for community learning, the regard toward librarians as information experts, and the broad base of membership (p. 118). However, she also notes the uncertainty with which public librarians regard information literacy and effective practices (p. 120). This uncertainty was also revealed by Bruce & Lampson in their study of librarians in Washington State (2002). A P-20 approach to library programs, and the IPBLE as a guideline for instruction, serve to address this uncertainty and promote a collaboration between the education sector, public libraries, and academic libraries in promoting information literacy through the development of expert thinking in information problem-solving.

This conceptual framework is supported by findings from this research.

Operational Framework of the IPBLE

The operational framework of the IPBLE is a guide for the development of an environment in which novices quickly develop expert thinking in the resolution of information problems embedded within a social and situational context. Thus, the IPBLE is not an environment in and of itself, nor a curriculum or training program. A more suitable analogy is a travel guide, which includes strategies for navigating the language, culture, and terrain of a travel destination.

The IPBLE framework is designed to be modified to suit each context in which it is implemented. There are three phases in the IPBLE design: development, application, and evaluation. The framework below is an outline for the development phase.

1. **Development Phase Procedure:** in this phase, a profile of the context in which the IPBLE will be employed is completed and analyzed; these contexts could include school, public, and academic library programs, or workplace training programs.

- a. Domain selection: in this first stage, a complete profile of the context is completed, including outcomes and competencies related to information problem-solving.
- b. Domain analysis: in this stage, the core content is determined, and factors impacting the context are identified; these factors include information needs and sources, stakeholder goals and environmental factors.
- c. Problem analysis: in this stage, an inventory of the types of problems inherent within this domain is completed; dimensions considered include external/internal characteristics and form of problems.
 - i. Problem characteristics:
 - 1. External characteristics of problems: structuredness, context, complexity, dynamicity, domain specificity (Jonassen, 2010, p. 6)
 - 2. Problem typology (Jonassen, 2010, p. 12)
 - 3. Internal characteristics of problem-solvers: prior domain knowledge, prior problem-solving experience, cognitive skills (Jonassen, 2010, p. 20)
 - 4. Problem forms: story problems, decision-making problems, troubleshooting problems, strategic performance problems, policy-analysis problems, design problems (Jonassen, 2010, p. 25)
 - ii. Problem functions/problems as cases (Jonassen, 2010, p. 150):
 - 1. Cases as problems to solve
 - 2. Cases as worked examples
 - 3. Case studies

4. Cases as analogies
 5. Cases as prior experiences
 6. Cases as alternative perspectives
 7. Cases as simulations
- iii. Information dimensions
1. Problem information: domain information, problem information, problem-solving information (Bystrom & Jarvelin, 1995)
 2. Information problem-solving process: Big6 (Eisenberg & Berkowitz, 1988)
- d. IPBLE implementation: training plan and timeline
- e. Assessment of information problem-solving learning (Jonassen 2010, p. 355)
- i. Assessing schema development
 1. Text editing/Jeopardy
 2. Problem classification
 3. Problem posing
 4. Student models
 - ii. Assessing information problem-solving performance
 1. Performance rubrics
 2. Argumentation
 3. Coding schemes
 4. Simulations/scenarios
 5. Student-constructed problems
 - iii. Assessing cognitive skills

iv. Assessing arguments in support of problem solutions

2. Application Phase Procedure

- a. Timeline for implementation
- b. Staff training
- c. Procurement of materials
- d. Establishment of norms and procedures
- e. Management of IPBLE
- f. Formative assessments
- g. Troubleshooting
- h. Closure

3. Evaluation of the IPBLE Phase Procedure

5.3.2 A Model of IPBLE for the Professional Librarian Preparatory Program

In a study of librarians in Washington State, Bruce & Lampson (2002) investigated their perceptions of roles as information literacy advocates and educators. They found that these librarians were uncertain, and in fact skeptical, of a standard definition or conception of information literacy. This uncertainty likely served as a barrier to effective advocacy. They also found that while librarians expressed concern over the need to teach information literacy skills, particularly the evaluation of information sources, they felt they did not have the training necessary to be effective in this role. Librarians in this study recognized that while they had confidence in their own information literacy proficiency, they felt inadequately prepared in the pedagogy of information literacy. This corroborates the literature on expertise that reveals experts are not necessarily effective in teaching the content of their domains (Bransford et al., 2000). As information professionals recognize and adopt the instructional component of

librarianship, there is a need for preparatory programs to respond. The Information Problem-Based Learning Environment also provides guidance in the design of professional librarian preparatory programs.

5.4 Chapter Summary

This research was motivated by a gap in the literature on information literacy. It was designed to bridge this gap between a conception of information literacy from the field of library and information science, and the abundant literature on the nature and impact of expert problem-solving behavior in a variety of domains. The research questions focused on proficiency at the crucial initial stage of the problem-solving process, a hallmark of expert thinking, within the problem-solver's domain of expertise. To investigate the nature of this thinking as domain general, the research questions also provided focus on the transfer of this type of expert thinking to non-expert domains. As a component of the research design, problem scenarios appropriate to a study from a library and information science perspective were operationalized as information problems, which included an inherent user need related to an area of information behavior as described by The Big6 model of the information problem-solving process. That these information problem scenarios required information not contained within the scenario itself defined them as ill-structured problems, a problem type not often addressed in empirical research. Data collected was analyzed in Chapter 4 and findings were discussed in this chapter.

Three essential questions emerged from the problem space identified by the literature:

- 1) Who are the experts in IPS?
- 2) How do they think?
- 3) Is their thinking transferable?

As discussed in this chapter, this research suggests answers to these questions. Trained and experienced librarians are experts in information problem-solving, and they think like experts in other domains. This creates an opportunity to apply the vast body of literature on expertise and expert performance to a more robust understanding of information problem-solving. This research also suggests that the expert thinking of librarians is transferable. The results are limited to the domains included in the study, but suggest a boost in those domains. There is a unique substrate in library and information science described by Bates (1999) that may provide the opportunity for expert thinking across a variety of domains.

Several findings discussed in Chapter 5 are related to expert thinking in information problem-solving. Training and experience in librarianship produces predictable expert behavior in information problem-solving, which suggests that a course of study, whether brief and targeted or ongoing and sustained, with a focus on Task Definition may promote expert information problem-solving. Moreover, like experts in other domains, librarians recognize the underlying information needs within information problems. Finally, metacognition plays a role in categorical determinations during Task Definition.

Other findings are related to bridging the gap between the study of information literacy within the field of library and information science, and the study of expertise and expert performance in the fields of cognitive science and the learning sciences. The expert thinking of librarians may be described by the expertise literature; further research is necessary to examine why surface feature similarities do affect categorical determinations made by librarians in information problem-solving. Methodological considerations are expanded, such as the ill-structured nature of information problems and the current repertoire of methods applied to information behavior

research. Moreover, a design shift in information systems and services toward Task Definition will facilitate expert information problem-solving.

The last set of findings are related to transfer. This research found that there is value in thinking like a librarian in multiple domains. This phenomenon may be explained by Bates' concept of information science as a meta-science, and suggests further research described in Chapter 6.

Moreover, information problem-solving expertise is comprised of multiple components, which may be explained by the concept of information components described by Bystrom & Jarvelin. Again, further research is suggested here and addressed in the next chapter.

Chapter 6 describes the contributions of this research, limitations, and the need for future work as suggested by this research.

6.0 Chapter 6: Contributions and Future Work

This chapter describes the theoretical, empirical, methodological, and pedagogical contributions of this research based on the findings discussed in Chapter 5. In this chapter, limitations of this research and the direction of future work are also discussed. Specific contributions are discussed in section 6.2, limitations of this research are discussed in section 6.3, and future work suggested by this research is discussed in section 6.4.

6.1 Introduction

The findings discussed in Chapter 5 suggest several exciting avenues for the study of information literacy. Expansion of Task Definition within the Big6 model, the application of a new repertoire of methods to the study of information behavior, and the testing of interventions designed to induce expert thinking in information problem-solving are among the initiatives inspired by this research.

6.2 Contributions

In this section, contributions of this research to the theory, research, methodology, and pedagogy related to information behavior in the field of library and information science are described.

Theoretical Contributions

- Training and experience in librarianship produces predictable expert behavior in information problem-solving.
- Librarians recognize the underlying information needs with information problems.
- The expertise of librarians may be described by the vast body of literature on expertise.
- Information problem-solving expertise is comprised of multiple components.

This research makes contributions to the theoretical approaches applied to information behavior research.

The foundation of the theoretical framework applied to this investigation is built on a conceptualization of constructivism developed by Kuhlthau (2004). Kuhlthau adds to Dewey's philosophical approach to knowledge construction the perspective of Kelly, who offered the Personal Construct Theory (1963). Included are theories of analogical problem-solving and structure-mapping (Gentner, 1983; Novick & Bassok, 2005). The model used to identify and describe the stages of the information problem-solving process is The Big6 (Eisenberg & Berkowitz, 1988). This framework proved to be appropriate in explaining the results of the data analyses.

The nature of Task Definition, the crucial initial stage of the information problem-solving process, may be described by analogical reasoning and structure-mapping theories. The impact of Task Definition on successful information problem-solving is described by The Big6 model.

This research validates the Big6 as a model of expert information problem-solving, and places an emphasis on the initial stage of Task Definition. It provides a more accurate and comprehensive description of the nature and impact of categorization in Task Definition during the information problem-solving process than was currently available, and inform a conception of information literacy. Task Definition within the Big6 may be expanded with the addition of literature on expert thinking from the fields of cognitive science and the learning sciences. Future work will focus on the development of the Big6 model.

The findings established that expert behavior in information problem-solving is predictable and nearly identical to expert behaviors tested empirically in cognate fields. This research enables the application of theories from the cognitive sciences and the learning sciences to a library and information science investigation; specifically, structure-mapping theory, analogical reasoning, and Cognitive Load Theory. This research also relates the literature on expertise and expert performance to information literacy as expertise in information problem-solving.

Competence versus Expertise

The contribution of this research to a theoretical framework for understanding information problem-solving behavior suggests a new line of inquiry: is it necessary to achieve a level of expertise to be a competent information problem-solver?

The study of competence has been the focus of research in management, learning science, and cognate fields. Many competencies describe effective behaviors that are expected as the result of training, experience, or instruction. Typically, these are observable and measurable. Many sets of competencies have been developed specifically to describe information literacy. This research

suggests a new approach to information problem-solving—to think like an expert. This approach focuses on the type of thinking that distinguishes experts from novices in a variety of domains. This type of thinking emphasizes problem type to determine the most effective solution strategy. However, expert thinking is a cognitive process that is not as easily observed and measure as behaviors. So, which approach is more appropriate in determining information behavior that results in successful information problem-solving?

To investigate Task Definition and its sub-stages, it may be useful to identify related behavioral competencies and their underlying cognitive processes. Eisenberg suggests that problem solvers “need to develop a range of competencies within each skill area” (Eisenberg & Berkowitz, 1990, p. 1) Management literature has identified, examined, and applied theories of behavioral competencies to successful job performance (Spencer & Spencer, 1993), and in project management roles (Taylor & Woelfer, 2010). This framework may be applied to an investigation of the competencies associated with Task Definition, and guide a future empirical investigation.

Empirical Contributions

- The expert thinking of librarians is demonstrated in variety of conditions.
- There is value in thinking like a librarian in multiple domains.
- Surface feature similarities do affect categorical determinations made by experts and novices.
- Information problems are ill-structured, but categorized during Task Definition.
- A design shift in information systems toward Task Definition will facilitate expert information problem-solving.

This research offers contributions to empirical research. The large body of literature on information needs illuminates the many facets of this area of information behavior research. As a process approach, The Big6 model of information problem-solving addresses a variety of related information behaviors, focusing on effectiveness in each. It describes two components of the initial stage of Task Definition: defining the problem, and identifying the information need to resolve the problem. This research targeted the first component, which has been only tangentially addressed by the information needs literature.

The findings of this research begin to shed light on this component, and taken together our understanding of information needs, provides a comprehensive picture of this behavior pattern. Moreover, this research examined the transfer of expert thinking, operationalized as categorization during Task Definition, to non-expert domains. While not conclusive, this research examined the assumption of information literacy skills as domain-general, and found that there is transfer to the domains examined in this research. This contribution suggests further examination of the three components of information problem-solving, as described by Bystrom & Jarvelin (1995), to determine the nature and impact of each.

This research may improve the performance of information systems and services by aligning goals with user's state of Task Definition.

Methodological Contributions

- The triad judgment task expands the repertoire of methods applied to information behavior research.

This research examined Task Definition within the information problem-solving process. To measure this phenomenon, the research design adapted a method used in cognitive science research. In this research, a common approach to studying the performance of experts is to study their performance on contrived tasks, which are tasks not typically undertaken (Chi, 2006b). This approach enables the controlling of task, context, and other variables in a laboratory setting, and enables a comparison to novice performance on the same task. Moreover, the contrived task may be designed to elicit behavior and reflection related to a particular and focused set of cognitive processes, in this case those engaged in Task Definition.

Hoffman (1995) describes types of contrived tasks that have typically been employed in the study of expert knowledge: recall, perceiving, categorizing, and verbal reporting. The triad judgment task is a categorizing task used to highlight differences between domain experts and novices in the way they categorize problems based upon surface or deeper structural features. This method was employed in the domains of engineering (Hardiman et al, 1989), statistics (Rabinowitz & Hogan, 2008), and teaching (Hogan & Rabinowitz, 2009). This method is well-established and well-suited to an examination of Task Definition; more specifically, the categorization of information problems based upon surface or deeper structural features during Task Definition within the process of information problem-solving. This research expands the current repertoire of methods used to investigate human information behavior.

Moreover, the research design called for the development of information problem scenarios. As a component of the research design, problem scenarios appropriate to a study from an LIS perspective were operationalized as information problems, which included an inherent user need related to an area of information behavior as described by The Big6 model of the information problem-solving process. That these information problem scenarios required information not

contained within the scenario itself defined them as ill-structured problems, a problem type not often addressed in empirical research. However, the information problems developed for this research did indeed yield the data expected.

The application of the repertory grid technique (RepGrid Technique), based on the theory of personal constructs by Kelly (1955) provided insights into the cognition of participants as they made categorical determinations of information problems. The data collected from this phase of the investigation served to triangulate the findings from the first phase, the online triad judgment tasks. Modification of the RepGrid Technique for use in this phase of the research, as determined by the research design, resulted in a limited range of data. The use of information problem scenarios that were constructed according to the requirements of the research design for the online triad judgment tasks prompted participants to make categorical determinations based on explicit elements within the scenarios, or implicit inferred elements. As it turned out, when participants sorted based on implicit inferred elements, their verbally-reported constructs reflected the stage of the information problem-solving process determined by the researcher. These results served to corroborate earlier findings, but did not yield new insight into the cognition of participants as they made categorical determinations.

The RepGrid Technique has been applied in a variety of ways (Tan & Hunter, 2002) in a variety of studies (Hunter, 1997; Moynihan 1996; Pythian & King, 1992), and holds the potential to yield insight into other areas related to the field of library and information science. Cognition is often studied at the level of the individual, but Tan & Hunter (2002) make a case for understanding cognition at the organizational level via the RepGrid Technique: “it is possible to understand organizational cognition and hence organizational action, by measuring and understanding individual cognition or personal constructs” (p. 40). This technique has been

applied to the study of managerial competencies (Cammock et al, 1995), but not yet to the role of a librarian within an organization. This line of inquiry is described in section 6.7.4.

Pedagogical Contributions

- Training and experience in librarianship produces predictable expert behavior in information problem-solving.
- Targeted and sustained interventions focused on Task Definition may promote expert information problem-solving.
- Metacognition plays a role in categorical determinations during Task Definition.
- The expert thinking of librarians is demonstrated in variety of conditions.
- There is value in thinking like a librarian in multiple domains.

This research validated the importance of Task Definition within the information problem-solving process, which is termed problem representation in the cognitive and learning science literatures. It also validated the role of trained and experienced librarians as experts in the process of solving problems requiring the identification, access, and evaluation of information. This expertise is developed through formal professional preparatory programs and related experiences within the field. While predictable, the expert information behavior applied to the categorization of information problems during Task Definition is not comprehensive; that is, not all trained and experienced librarians who participated demonstrated this expert behavior. Moreover, according to the characteristics of experts described by the literature, experts are not always effective in teaching their craft (Bransford et al., 2000)

These findings suggest a revision of the pedagogy in information literacy instruction in multiple environments by refocusing on Task Definition. This refocus involves implementation of the following research-based strategies for the development of Task Definition proficiencies:

- The Big6 Process Approach (Eisenberg & Berkowitz)
- Case-Based Learning in Problem-Based Learning Environments (Jonassen, 2011)
- Multiple Analogs (Gick & Holyoak, 1983)
- Worked Examples (Atkinson, Derry, Renkl, & Wortham, 2000)
- Kinesthetic Representation (Catrambone, Craig, & Nersessian, 2006)
- Storytelling (Klein, 1998)

The principles of Task Definition proficiency are appropriate on two levels: teacher-librarian preparatory programs, and instruction in library programs. Moreover, they apply to educational content standards, including the Common Core State Standards (Initiative, 2010).

6.3 Limitations

Every effort was made in the research design to identify the most appropriate method for the research questions investigated. However, the process of method selection balances acceptable levels of internal and external validity. Moreover, the operationalization of concepts from the theoretical framework will introduce further compromises. In this section, these limitations are addressed.

Methods

The nature of Task Definition, which includes the definition of the information problem and identification of the information needed to resolve the problem, is inherently difficult to measure as it is not an observable behavior. Therefore, methods designed for the measure of this type of

phenomenon were incorporated into the research design. In cognitive science research, a common approach to studying the performance of experts is to study their performance on contrived tasks, which are tasks not typically undertaken (Chi, 2006b). This approach enables the controlling of task, context, and other variables in a laboratory setting, and enables a comparison to novice performance on the same task. The researcher has proposed that these tasks are representative of the type of information problems typically encountered by a professional librarian, and that the cognitive process of categorical determination occurs during any problem encounter. However, as a contrived task, the triad judgment task method is limited in the accuracy with which it predicts Task Definition behavior in real-world contexts, and limits the generalizability of findings.

Clear and consistent sampling techniques support statistical validity. This research employed a variety of sampling techniques. In phase 1, the population of trained and experienced librarians was convenience sampled via direct online recruitment of all librarians in the Washington State Library employee database, whereas the population of non-librarians was convenience sampled via direct face-to-face recruitment of students enrolled in undergraduate courses in the informatics program at the University of Washington. In phase 2, experts were recruited via subsampling the sample group from phase 1; whereas novices were recruited partially via subsampling of phase 1 participants and partially via snowball sampling. The latter technique resulted in the recruitment of several participants from the same engineering course. The introduction of a variety of sampling techniques will add sampling errors and compromise statistical validity. The researcher addressed any concern over the power of the statistical tests through the recruitment of a large number of participants, in addition to the effect size and the

alpha level set in the statistical analyses. The suite of tests employed were powerful enough to detect differences in means between sample groups.

Furthermore, factors that were not the focus of this research, namely age and level of education, may play a role in the categorization of information problems during Task Definition. This research found significant differences between trained and experienced librarians and non-librarians only. This limitation may be overcome with replication of the research with sample groups controlled for age and education level.

Operationalizations

The operationalization of concepts identified by the theoretical framework introduce challenges to construct validity. The domains of everyday life situations and statistics were selected to represent a near domain and a far domain, respectively. However, these domains included may not be representative of actual domains in which transfer may occur. Moreover, findings related to transfer are relegated to these domains. Moreover, in prior research, both methods have been applied to well-structured problems; information problems are not well-structured. These limitations may be overcome through replication of this research with alternate domains and problem scenarios.

Another limitation is related to the nature of information problem-solving skills. While this research found that expert participants in this study did categorize information problems in non-expert domains based on underlying principles as would be expected of experts in other domains, the distinction between those skills that are generalizable to novel problems and domains and those that are specific to the domains under study remains ambiguous.

6.4 Future Work

This research addressed gaps in the current literature related to information literacy.

Investigation of this problem space revealed directions for further investigation, including continued examination of the nature and impact of Task Definition, the structure of targeted and sustained interventions that develop expert information problem-solving skills, and the efficacy of professional teacher-librarian preparatory programs. The findings of this research guide the direction of this future work related to information literacy within the discipline of information behavior.

6.4.1 Replication of Research Findings

Age and Education Level

It is beyond the scope of this research to determine the roles of age and education level in the demonstration of expert thinking, but an obvious extension. Reading literacy as a component of education level plays an important role in a problem-solving process requiring the access, evaluation, and use of text-based information. This research recruited participants from Washington State, but reading literacy can vary from state to state. This research may be replicated with participants from a geographically and demographically diverse state, such as South Carolina, with an emphasis on age and education level, and will answer the following research question:

- **To what degree do the factors of age and education level affect categorical determinations of information problems?**

Components of an Information Problem

Bystrom & Jarvelin (1995) described three components of information problems: domain information, problem information, and problem-solving information. This research exposed the importance of problem-solving information, and prompts the need to investigate the nature and impact of the second component of problem information that is specific to the type of problem situated within its domain—problem information. This research will answer the following research question:

- **What is the relationship between expert information problem-solving and the three components of an information problem?**

6.4.2 Information Literacy Programming

Schema Induction and Information Problem-Solving

To take the examination of Task Definition further, it will be necessary to test related principles of analogical thinking as applied to information problem-solving. Studies by Gick & Holyoak (1980, 1983) offer findings relevant to the development of expert thinking and information problem-solving skills. In their studies of analogical reasoning, they found that two or more direct analogies, with essentially similar deeper structures, may be dramatically more effective than one. One analogous story may not be enough to call attention to the underlying structure, and a second may do just that; an analogous story that is only partially similar, or only superficially similar, will not produce this effect (Gick & Holyoak, 1980). This approach to understanding the acquisition of expert thinking skills in the solution of information problems suggests an exciting and promising line of inquiry that investigate the following research question:

- **How can principles of analogical reasoning and structure-mapping theory be applied to an understanding of Task Definition?**

The Structure of Targeted and Sustained Interventions That Develop Expert Information Problem-Solving Skills

A targeted approach can produce immediate changes in information problem-solving behavior. With the current focus on students' difficulties in discerning fact from fiction in online information, several entities have responded with targeted lessons, tools, and strategies—but the research needs to catch up to identify best practices. These targeted approaches focus on the evaluation of information, addressed in the second stage of the Big6 model of information problem-solving, in which problem-solvers evaluate the credibility of their sources of information. This research asks the question:

- **What are the principles of a targeted intervention that produces immediate changes in information problem-solving behavior?**

Results of this research provide the principles for a learning environment that promotes expert information problem-solving. This sustained intervention is based on the concept of the Problem-Based Learning Environment (PBLE) developed by David Jonassen (2010) and modified by the integration of The Big6 model of information problem-solving by Eisenberg & Berkowitz (1988). This type of intervention encompasses the entire process of information problem-solving, and is intended to apply the findings of this research in the development of expert thinking within a domain. This research investigates the question (a detailed account of this concept may be found in Chapter 5):

- **What is the impact of a library program designed on the principles of the Information Problem-Solving Learning Environment?**

A component of this concept is to broaden the reach of the school library program. P-20 refers to an integrated education system that extends from pre-school through graduate study. It applies to a new and broader conception of library programs that embrace an emphasis on IL instruction that has been the keystone of school library programs. Examples:

- VIEWS2 Initiative which promotes Pre-K early learning through public library story times.
- Academic Library Instruction Programs which promote collaborations between librarians/faculty to bring information literacy skills directly to students.

Moreover, student competencies in information problem-solving must clearly articulated and assessed. Lloyd and other LIS scholars identify a transfer failure of information problem-solving proficiency from formalized educational contexts to everyday life context; she cites a lack of collaboration between the education sector and public libraries (Lloyd, 2010, p. 123). A P-20 approach to library programs, with guidelines for the establishment of an IPBLE, is intended to promote such a collaboration.

The Structure of Preparatory Programs in Librarianship

In a study of librarians in Washington State, Bruce & Lampson (2002) investigated their perceptions of roles as information literacy advocates and educators. They found that these librarians were uncertain, and in fact skeptical, of a standard definition or conception of information literacy. This uncertainty likely served as a barrier to effective advocacy. They also found that while librarians expressed concern over the need to teach information literacy skills,

particularly the evaluation of information sources, they felt they did not have the training necessary to be effective in this role. Librarians in this study recognized that while they had confidence in their own information literacy proficiency, they felt inadequately prepared in the pedagogy of information literacy. This corroborates the literature on expertise that reveals experts are not necessarily effective in teaching the content of their domains (Bransford et al., 2000). As information professionals recognize and adopt the instructional component of librarianship, there is a need for preparatory programs to respond.

The next level in the development of expert thinking in information problem-solving is the professional teacher-librarian preparatory program. Student competencies in information problem-solving must clearly articulated and assessed. This research will examine the current set of program competencies, and explore opportunities and best practices in the development of expert thinking and Task Definition, addressing the following research question:

- **How can the principles of Task Definition and expert thinking apply to the librarian preparatory program?**

6.4.3 Organizational Impact of Change-Agent Librarians

Librarianship at the Point of Need: Data, Diversity, Disease, and Disaster

Librarians need to reach beyond the library and find ways to meet students at their point of need: data, diversity, disease, disaster (Lankes, 2016). The application of the RepGrid Technique, based on Kelly's personal construct theory (1955), proved to yield data corroborating the results of the first phase of this investigation. However, it demonstrated potential for a further investigation examining the role of the librarian embedded within an organization. A focus on the managerial competencies of this role will yield insight into the impact of this role within an

organization (Cammock, Nilakant, & Dakin, 1995). According to Tan & Hunter (2002), the “RepGrid and its mapping outcomes can be used for individual and organizational level intervention” (p. 53). Application of all features of this method will enable a quantitative and qualitative analysis of this impact.

This investigation will focus on cases in a variety of contexts in which the role of a trained and experienced librarian is included in the organizational structure. These contexts will include school systems, hospitals, corporations, law firms, and ad hoc communities formed as the result of natural disaster. To measure such an impact, it will be necessary to first identify individuals regarded by those within and outside of the organization as demonstrating leadership and service to members of the organization. For each context, it will be necessary to develop criteria for identifying these individuals, and then a set of incentives for participation in the study. This method requires the participation of several other members of the organization, in addition to the librarian, so criteria for the selection of organizations from which high participation may be expected must be determined. Other components of the research design include the RepGrid Technique protocol, strategies for data collection and analysis, and plans for the dissemination of findings. This research will investigate these research questions:

- **How can the concept of “librarianship at the point of need” be developed to enhance the effectiveness of P-20 library programs?**
- **What is the impact of the librarian embedded within organizations in promoting effective information sources, formats, and channels, and in contributing to effective resolutions to information problems within the organization?**

6.5 Chapter Summary

The information age offers ready access to the information we need to navigate the challenges we face. Successful navigation, however, requires facility in the identification, access, evaluation, synthesis, application, and sharing of information throughout the problem-solving process. Information literacy describes this type of expertise. The cognate literature suggests that experts in a variety of domains are better at solving problems within their domain than novices because they are better at the initial stage of the process, where problem situations are “sized up” and categorized according to problem situations successfully resolved in past experiences. Yet little is known about the experts in information problem-solving, and how they categorize at the initial stage of the process, termed Task Definition. Definitions and descriptions of information literacy suggest that these skills are domain-general rather than domain-specific, yet no research to date has focused on the task definition of expert information problem-solvers across content domains. This research identifies and describes expertise in information problem-solving, the nature and impact of expert information problem-solving thinking, and the transfer of information problem-solving expertise. Specifically, how information problems are categorized by experts and novices, and whether expertise is transferable across domains.

Appendices

Appendix A: Information Problem Scenarios

Set 1 Scenarios

Domain Information: Librarianship

Surface and Deeper Structural Features

Librarianship		Surface Features				
		Neighbor + Political Processes	Medical Professional + Health Information	College Student + US Electoral College	Elementary Student + Careers	High School Student + World War II Events
Deeper Structural Features	TD	TD-1 A neighbor received an email message with background information	TD-2 A physician in a large hospital is putting together a treatment plan	TD-3 A student at a large university is conducting research on	TD-4 An elementary school student	TD-5 A high school student is working on

		and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change, a topic she is very much interested in. She is preparing to write an email message to her senator, and is considering the topics she would like to address in her message.	for a patient with colon cancer. The physician has determined a number of promising options, including naturopathic options. She would like to make a request to the hospital board for an increase in funding for naturopathic treatment options, but is having trouble putting together the proposal. She is uncertain of the specific treatments she wants to include in the proposal, and the sort of evidence she would need to make a strong case for each.	the U.S. Electoral College. The student has identified the search terms that she will use in her search for information, and discovers that there are several perspectives on the topic. She needs to determine the approach she would like to take in her research, whether she will present a case in support of the Electoral College system, or against it.	is working on an assignment for a unit on future careers. The library teacher asks her to list the kinds of questions she wants to address, and the information she will need to address them. The student explains that she will be making a presentation to the class on a career in law enforcement, and is thinking about focusing on either the kinds of training necessary or the types of related jobs that are available.	an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.
IA	IA-1 A friend in the neighborhood received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She would like to find out more about ocean variability, volcanic activity, and solar output within the last decade, to include in her message.	IA-2 A physician assistant in a large hospital is putting together a treatment plan for a patient with colon cancer. She has determined a number of management techniques and would like to provide a reference guide to the patient, but is uncertain about how to find information about each technique and for the numerous side effects related to chemo therapy.	IA-3 A student enrolled in a political science course at a large university is conducting research on the U.S. Electoral College. The student identified the search terms that she will use in her search for information on her topic, and finds a number of book and article titles appearing in a search results list. She is uncertain about how to find each item on the list.	IA-4 An elementary school student is working on an assignment for a unit on future careers. The student explains to the librarian that she will be making a presentation to the class on a career in law enforcement, and will cover the kinds of training necessary, the types of related jobs that are available, and the average salary for these jobs. She is frustrated by finding only one outdated book in the library related to law enforcement.	IA-5 A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the	

						end of the article.
IE	IE-1 An acquaintance in the neighborhood mentions receiving an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She is also unfamiliar with the organization that sent her the email message, and would like to find out more about this organization before sending the message.	IE-2 An oncologist in a large hospital is putting together a treatment plan for a patient with colon cancer. The oncologist has determined a number of management techniques. The patient has asked her to recommend naturopathic treatments as possible options, but the oncologist is unfamiliar with these options. The oncologist has compiled a number of sources describing clinical trials of promising naturopathic treatments, but she is uncertain about the reliability of these sources.	IE-3 A student at a large university is in the campus library conducting research on the U.S. Electoral College. The student has identified the search terms that she has used for her search, and points out a number of book and article titles appearing in a search results list. The student is uncertain about how to determine the point of view in each.	IE-4 An elementary school student is working on an assignment for a unit on future careers. The librarian asks her to explain the assignment, and list the kinds of questions she wants to address. The student explains that she will be making a presentation to the class on a career in law enforcement. She has found several websites related to law enforcement training, career paths, and salaries, but some seem to be recruiters and others are blogs clearly critical of law enforcement.	IE-5 A high school student needs help with her world history class assignment. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student decides to find out more about the Holocaust, and finds a long list of websites related to the Holocaust. She discovers that some of the websites are posted by groups that deny the Holocaust actually occurred, and is skeptical of the others.	

Set 2 Scenarios

Domain Information: Everyday Life Situations

Surface and Deeper Structural Feature Narratives

Everyday Life Situations		Surface Features		
		Financial Systems: Mortgage Financing	Travel Information: Hotel Accommodations	Consumer Advocacy: Automobile Purchasing
Deeper Structural Features	TD	TD-1 After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over how to begin the process of securing financing. You consider the kinds of questions you need to	TD-2 You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find an accommodation in an appealing neighborhood. You have never traveled abroad before, and are uncertain over what you need to know before making a decision that	TD-3 Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over your needs and which make and model will best suit them. You think about the amount you are willing to spend and the type of driving you expect to do, but still feel

		ask, and the places you need to go to find out more.	will affect your enjoyment of the trip.	overwhelmed about how to begin the process.
	IA	IA-1 After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. Your real estate agent has asked you to determine the amount of financing for which you are pre-approved, but you are not sure of how to approach the lending sources you have identified.	IA-2 You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find out more about accommodations in two appealing neighborhoods recommended to you by friends.	IA-3 Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over which make and model will best suit your driving needs and the amount you are willing to spend. A friend recommends an online auto review site, but you are unfamiliar with the website and how to get the information you need from it.
	IE	IE-1 After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. You have approached two lending sources to determine a pre-approval amount, but have received two very different figures. You are uncertain over how to decide which offer to take.	IE-2 You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, but have determined two appealing neighborhoods based upon your research. You have identified two accommodations that interest you: one recommended by a work colleague, and one recommended by an online travel advisory website. You need to find a way to evaluate these recommendations before making your choice.	IE-3 Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, and have determined your driving needs and the amount you are willing to spend. You have identified three different vehicles that appear to suit your needs: one recommended by an online auto review website, one recommended in an online auto blog, and one recommended by a family friend. You are uncertain over which one to choose.

Set 3 Scenarios

Domain Information: Statistics

Surface and Deeper Structural Feature Narratives (Quilici & Mayer, 1996)

Statistics		Surface Features		
		Psychology: fatigue and mental alertness	Academia: reading skill and GPA	Management: experience and typing speed
Deeper Structural Features	t	t-1 A psychologist tests the hypothesis that fatigue affects mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented	t-2 A college dean claims that good readers earn better grades than poor readers. The grade point averages (GPA) are recorded for 50 first-year students who scored high on a reading comprehension test and for 50 first-year students	t-3 A personnel expert wishes to determine whether experienced typists are able to type faster than inexperienced typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e.,

		during a 90-minute period, and the psychologist records the number of errors for each subject. Two groups of subjects are selected. The first group of 10 subjects is tested after they have been kept awake for 24 hours. The second group of 10 subjects is tested in the morning after a full night's sleep.	who scored low on a reading comprehension test.	with less than 5 years of experience) are given a typing test. Each typist's average number of words typed per minute is recorded.		
x	x-1	A psychologist tests the hypothesis that people who are fatigued also lack mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are selected; half are tested after being kept awake for 24 hours, and half are tested in the morning after a full night's sleep. Based on their number of errors on the test, each subject is also labeled as high or low in mental alertness.	x-2	A college dean claims that a group of good readers contains more honors students than a group of poor readers. For each of 100 first-year college students, a reading comprehension test was used to determine whether the student was a good or poor reader and grade point average (GPA) was used to determine whether or not the student was an honors student.	x-3	A personnel expert wishes to determine whether or not experienced typists are likely to be fast typists and inexperienced typists are more likely to be slow typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Based on the test, each typist is classified as fast or slow.
r	r-1	A psychologist tests the hypothesis that fatigue is related to mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are given this test, each with a different number of hours since they woke up (ranging from 1 to 20).	r-2	A college dean claims that scores on a reading comprehension test predict college grades. The grade point averages (GPA) and reading comprehension scores are recorded for 100 first-year students.	r-3	A personnel expert wishes to determine whether typing experience goes with faster typing speeds. Forty typists are asked to report how many years they have worked as typists and are given a typing test to determine their average number of words typed per minute.

Complete List of Scenarios + Supplemental Scenarios

Librarianship Scenarios

Each letter-number pair represents an information problem scenario: TD = Task Definition, IA = Information Access, IE = Information Evaluation; 1 = cover story about political processes, 2 = cover story about health information; 3 = cover story about research strategies

TD-1 A neighbor received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change, a topic she is very much interested in. She is preparing to write an email message to her senator, and is considering the topics she would like to address in her message.

TD-2 A physician in a large hospital is putting together a treatment plan for a patient with colon cancer. The physician has determined a number of promising options, including naturopathic options. She would like to make a request to the hospital board for an increase in funding for naturopathic treatment options, but is having trouble putting together the proposal. She is uncertain of the specific treatments she wants to include in the proposal, and the sort of evidence she would need to make a strong case for each.

TD-3 A student at a large university is conducting research on the U.S. Electoral College. The student has identified the search terms that she will use in her search for information, and discovers that there are several perspectives on the topic. She needs to determine the approach she would like to take in her research, whether she will present a case in support of the Electoral College system, or against it.

TD-4 An elementary school student is working on an assignment for a unit on future careers. The library teacher asks her to list the kinds of questions she wants to address, and the information she will need to address them. The student explains that she will be making a presentation to the class on a career in law enforcement, and is thinking about focusing on either the kinds of training necessary or the types of related jobs that are available.

TD-5 A high school student is working on an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.

IA-1 A friend in the neighborhood received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She would like to find out more about ocean variability, volcanic activity, and solar output within the last decade, to include in her message.

IA-2 A physician assistant in a large hospital is putting together a treatment plan for a patient with colon cancer. She has determined a number of management techniques and would like to provide a reference guide to the patient, but is uncertain about how to find information about each technique and for the numerous side effects related to chemo therapy.

IA-3 A student enrolled in a political science course at a large university is conducting research on the U.S. Electoral College. The student identified the search terms that she will use in her search for information on her topic, and finds a number of book and article titles appearing in a search results list. She is uncertain about how to find each item on the list.

IA-4 An elementary school student is working on an assignment for a unit on future careers. The student explains to the librarian that she will be making a presentation to the class on a career in law enforcement, and will cover the kinds of training necessary, the types of related jobs that are available, and the average salary for these jobs. She is frustrated by finding only one outdated book in the library related to law enforcement.

IA-5 A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the end of the article.

IE-1 An acquaintance in the neighborhood mentions receiving an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She is also unfamiliar with the organization that sent her the email message, and would like to find out more about this organization before sending the message.

IE-2 An oncologist in a large hospital is putting together a treatment plan for a patient with colon cancer. The oncologist has determined a number of management techniques. The patient has asked her to recommend naturopathic treatments as possible options, but the oncologist is unfamiliar with these options. The oncologist has compiled a number of sources describing clinical trials of promising naturopathic treatments, but she is uncertain about the reliability of these sources.

IE-3 A student at a large university is in the campus library conducting research on the U.S. Electoral College. The student has identified the search terms that she has used for her search, and points out a number of book and article titles appearing in a search results list. The student is uncertain about how to determine the point of view in each.

IE-4 An elementary school student is working on an assignment for a unit on future careers. The librarian asks her to explain the assignment, and list the kinds of questions she wants to address. The student explains that she will be making a presentation to the class on a career in law enforcement. She has found several websites related to law enforcement training, career paths, and salaries, but some seem to be recruiters and others are blogs clearly critical of law enforcement.

IE-5 A high school student needs help with her world history class assignment. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student decides to find out more about the Holocaust, and finds a long list of websites related to the Holocaust. She discovers that some of the websites are posted by groups that deny the Holocaust actually occurred, and is skeptical of the others.

Everyday Life Scenarios

Each letter-number pair represents an information problem scenario: TD = Task Definition, IA = Information Access, IE = Information Evaluation; 1 = cover story about mortgage financing, 2 = cover story about travel accommodations; 3 = cover story about automobile purchasing

TD-1 After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over how to begin the process of securing financing. You consider the kinds of questions you need to ask, and the places you need to go to find out more.

TD-2 You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find an accommodation in an appealing neighborhood. You have never traveled abroad before, and are uncertain over what you need to know before making a decision that will affect your enjoyment of the trip.

TD-3 Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over your needs and which make and model will best suit them. You think about the amount you are willing to spend and the type of driving you expect to do, but still feel overwhelmed about how to begin the process.

IA-1 After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. Your real estate agent has asked you to determine the amount of financing for which you are pre-approved, but you are not sure of how to approach the lending sources you have identified.

IA-2 You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find out more about accommodations in two appealing neighborhoods recommended to you by friends.

IA-3 Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over which make and model will best suit your driving needs and the amount you are willing to spend. A friend recommends an online auto review site, but you are unfamiliar with the website and how to get the information you need from it.

IE-1 After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. You have approached two lending sources to determine a pre-approval amount, but have received two very different figures. You are uncertain over how to decide which offer to take.

IE-2 You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, but have determined two appealing neighborhoods based upon your research. You have identified two accommodations that interest you: one recommended by a work colleague, and one recommended by an online travel advisory website. You need to find a way to evaluate these recommendations before making your choice.

IE-3 Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, and have determined your driving needs and the amount you are willing to spend. You have identified three different vehicles that appear to suit your needs: one recommended by an online auto review website, one recommended in an online auto blog, and one recommended by a family friend. You are uncertain over which one to choose.

Statistics Scenarios (used with permission from Quilici & Mayer, 1996)

Each letter-number pair represents a sorting problem: t = t test, x = chi-square, r = correlation; 1 = cover story about experience and typing speed; 2 = cover story about temperature and precipitation; 3 = cover story about fatigue and mental alertness; 4 = cover story about reading skill and grade point average.

t-1 A psychologist tests the hypothesis that fatigue affects mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Two groups of subjects are selected. The first group of 10 subjects is tested after they have been kept awake for 24 hours. The second group of 10 subjects is tested in the morning after a full night's sleep.

t-2 A college dean claims that good readers earn better grades than poor readers. The grade point averages (GPA) are recorded for 50 first-year students who scored high on a reading comprehension test and for 50 first-year students who scored low on a reading comprehension test.

t-3 A personnel expert wishes to determine whether experienced typists are able to type faster than inexperienced typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Each typist's average number of words typed per minute is recorded.

t-4 After examining weather data for the last 50 years, a meteorologist claims that the annual precipitation is greater in years with below average temperature than in years with above average temperature. She notes the annual rainfall for each of 25 years that had above average temperatures as well as 25 years that had below average temperatures.

x-1 A psychologist tests the hypothesis that people who are fatigued also lack mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are selected; half are tested after being kept awake for 24 hours, and half are tested in the morning after a full night's sleep. Based on their number of errors on the test, each subject is also labeled as high or low in mental alertness.

x-2 A college dean claims that a group of good readers contains more honors students than a group of poor readers. For each of 100 first-year college students, a reading comprehension test was used to determine whether the student was a good or poor reader and grade point average (GPA) was used to determine whether or not the student was an honors student.

x-3 A personnel expert wishes to determine whether or not experienced typists are likely to be fast typists and inexperienced typists are more likely to be slow typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Based on the test, each typist is classified as fast or slow.

x-4 After examining weather data for the last 50 years, a meteorologist claims that the annual precipitation is more likely to be above average in years when the temperature is above average than

when temperature is below average. For each of 50 years, she notes whether the annual rainfall is above or below average and whether the temperature is above or below average.

r-1 A psychologist tests the hypothesis that fatigue is related to mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are given this test, each with a different number of hours since they woke up (ranging from 1 to 20).

r-2 A college dean claims that scores on a reading comprehension test predict college grades. The grade point averages (GPA) and reading comprehension scores are recorded for 100 first-year students.

r-3 A personnel expert wishes to determine whether typing experience goes with faster typing speeds. Forty typists are asked to report how many years they have worked as typists and are given a typing test to determine their average number of words typed per minute.

r-4 After examining weather data for the last 50 years, a meteorologist claims that the annual precipitation varies with average temperature. For each of 50 years, she notes the annual rainfall and average temperature.

Appendix B: Permission by Author to Use Scenarios

Communication Dated 12/23/16

Thank you, Jill. Yes, I am interested only in those that were published. I am very excited about moving ahead with this research!

Cheers,

John Marino
PhD Candidate
Information School, UW
marinoj@uw.edu
Twitter: @marinojuw

From: Quilici, Jill L [<mailto:jill.quilici@csun.edu>]
Sent: Friday, December 23, 2016 9:03 AM
To: John Marino <marinoj@uw.edu>
Subject: Re: Request for Permission to Use Word Problems

Hi John,

It is fine with me if you use them. However, you will need to use the problems that are published in the article. There weren't many other problems beyond those, and I don't have them saved in a file that will still open, because it is from so long ago. I hope that is not a problem.

Best,

Jill

Jill L Quilici, Ph.D.

Professor
Department of Psychology
California State University, Northridge
18111 Nordhoff St.
Northridge, CA 91330-8255
Office: Sierra Tower 333
Phone: 818-677-7120
e-mail: jill.quilici@csun.edu

From: John Marino <marinoj@uw.edu>
Date: Tuesday, December 20, 2016 at 11:00 AM
To: Jill Quilici <jill.quilici@csun.edu>
Subject: Request for Permission to Use Word Problems
Resent-From: Jill Quilici <jill.quilici@csun.edu>

Dr. Quilici-

I am a PhD candidate in the Information School at the University of Washington. I am interested in the cognitive process of problem representation, and have been informed by the studies you have conducted with Richard E. Mayer related to structural awareness theory.

In the field of library and information science, we are interested in how and when people recognize the need to access new information. I am designing a study investigating the way people categorize information problems, and would like to include the statistics word problems used in your study, "Role of Examples in How Students Learn to Categorize Statistics Word Problems" (1996).

I am hoping you will agree to allow me to use these statistics word problems in my research study, with full citation, of course.

Cheers,

John Marino
PhD Candidate
Information School, UW
marinoj@uw.edu
Twitter: @marinojuw

Appendix C: Full Text of Investigation 1 (Triad Judgment Task)

Screen 1:

Sorting Information Problems

Welcome!

This study investigates the way people embark upon solving problems or managing situations in which more information is needed. Your participation in this study is essential to better understand the

information problem-solving process, guide the development of educational programs to improve information skills, and suggest improvements to the design of information systems and services.

You will be asked to complete a number of decision tasks. In each decision task, you will read a brief scenario called the “target scenario.” You will then read two other brief scenarios, and choose the one that goes best with the target scenario. There are 30 decision tasks in all that include scenarios from a variety of situations.

You are encouraged to move quickly through the decision tasks; the time for completion of all decision tasks should be less than 30 minutes. As an acknowledgment of your time, you are eligible to participate in a drawing for one of several \$50 gift cards.

Note: Scenarios are best viewed with Firefox or Google Chrome browsers.

Questions or Comments?

Contact John Marino at marinoj@uw.edu

Screen 2:

Sorting Information Problems

UNIVERSITY OF WASHINGTON PARTICIPANT INFORMATION

The purpose of this section is to give you the information you will need to help you decide whether to be in this research study or not. Please read this information carefully. You may ask questions about the purpose of the research, what you are being asked to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this section that is not clear. You are completely free to decide if you want to be in this study or not. This process is called “informed consent.” Please contact the researcher for a copy of this information if you would like it for your records.

PURPOSE OF THE STUDY

This is a study of information behavior, with a focus on the way people solve problems or manage situations in which further information is needed. In this study, these problems or situations are called information problems. Typically, when individuals encounter an information problem in their work or everyday lives, they embark on a process called information problem-solving. The purpose of this study is to examine the way that individuals sort information problems in a variety of situations.

STUDY PROCEDURES

If you choose to participate in this study, you will be asked to complete a number of decision tasks. In each decision task, you will read a brief scenario called the “target scenario.” You will then read two other brief scenarios, and choose the one that goes best with the target scenario. There are 30 decision tasks in all that include scenarios from a variety of situations. The estimated time for completion of all decision tasks is 30 minutes.

You will be asked to provide some demographic information to enable analysis of decision task responses. You will then be asked to provide contact information only if you choose to be included in a random drawing for one of several gift certificates.

You will also be asked if you would be willing to participate in a follow up research activity that will provide additional information related to the decision tasks. Agreeing to participate in this research activity will also require that you provide contact information.

You may refuse to answer any question and end your participation in the study at any time.

RISKS, STRESS, OR DISCOMFORT

We do not anticipate any risks or discomfort to you from your participation in this study. Any data collected from you in this study will be coded and kept confidential. However, summarized data and anonymized excerpts from research activities may be published in research reports and presentations. You may refuse to participate or withdraw from the study at any time.

It is important that you promptly tell the lead researcher if you believe that you have been harmed because of taking part in this study. You can tell the researcher in person or call the number listed. This number is monitored 24 hours a day.

The UW does not normally provide compensation for harm except through its discretionary program for medical injury. However, the law may allow you to seek other compensation if the harm is the fault of the researcher. You do not waive any right to seek payment by agreeing to participate in this study.

BENEFITS OF THE STUDY

You may not directly benefit from taking part in this study. If you choose to be included in a random drawing, you may receive one of several \$50 gift certificates; gift certificates will be provided within one week after data has been collected. Your participation in the study, however, may contribute to a better understanding of human information behavior, suggest improvements for the design of information systems and services, and guide the development of educational programs to improve information problem-solving skills in schools, work environments, and everyday life.

CONFIDENTIALITY OF RESEARCH INFORMATION

Data collected for this study will remain confidential. Your responses will be identified by randomly-generated codes. Any contact information you provide for the random drawing or for participating in the follow up research activity will also remain confidential, and will be kept only until the completion of your participation in the study.

OTHER INFORMATION

You may refuse to participate and you are free to withdraw from this study at any time without penalty or loss of benefits to which you are otherwise entitled.

This study has been approved by UW IRB #50222.

CONTACTS

If you have any questions about this study or your participation in it, please contact:

John L. Marino, Jr., Doctoral Candidate, Information School, University of Washington,
marinoj@uw.edu, (206) 271-7691

If you have any questions about your rights as a research participant, please contact:

University of Washington Human Subjects Division, hsdinfo@uw.edu, (206) 543-0098

AGREEMENT

By clicking "Next" below, you acknowledge that the purpose and nature of this research have been sufficiently explained to you and that you agree to participate in this study. You also acknowledge that you are over 18 years old, and understand that you are free to withdraw at any time without incurring any penalty.

Screens 3-32:

Decision Task 1/30

Question 1

Target Scenario:

A neighbor received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change, a topic she is very much interested in. She is preparing to write an email message to her senator, and is considering the topics she would like to address in her message.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A friend in the neighborhood received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She would like to find out more about ocean variability, volcanic activity, and solar output within the last decade, to include in her message.

Scenario B: A physician's assistant in a large hospital is putting together a treatment plan for a patient with colon cancer. She has determined a number of management techniques and would like to provide a reference guide to the patient, but is uncertain about how to find information about each technique and for the numerous side effects related to chemo therapy.

Scenario A

Scenario B

Decision Task 2/30

Question 2

Target Scenario:

A student enrolled in a political science course at a large university is conducting research on the U.S. Electoral College. The student identified the search terms that she will use in her search for information on her topic, and finds a number of book and article titles appearing in a search results list. She is uncertain about how to find each item on the list.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: An elementary school student is working on an assignment for a unit on future careers. The librarian asks her to explain the assignment, and list the kinds of questions she wants to address. The student explains that she will be making a presentation to the class on a career in law enforcement. She has found several websites related to law enforcement training, career paths, and salaries, but some seem to be recruiters and others are blogs clearly critical of law enforcement.

Scenario B: A student at a large university is in the campus library conducting research on the U.S. Electoral College. The student has identified the search terms that she has used for her search, and points out a number of book and article titles appearing in a search results list. The student is uncertain about how to determine the point of view in each.

Scenario A

Scenario B

Decision Task 3/30

Question 3

Target Scenario:

An oncologist in a large hospital is putting together a treatment plan for a patient with colon cancer. The oncologist has determined a number of management techniques. The patient has asked her to recommend naturopathic treatments as possible options, but the oncologist is unfamiliar with these options. The oncologist has compiled a number of sources describing clinical trials of promising naturopathic treatments, but she is uncertain about the reliability of these sources.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A physician in a large hospital is putting together a treatment plan for a patient with colon cancer. The physician has determined a number of promising options, including naturopathic options. She would like to make a request to the hospital board for an increase in funding for naturopathic treatment options, but is having trouble putting together the proposal. She is uncertain of the specific treatments she wants to include in the proposal, and the sort of evidence she would need to make a strong case for each.

Scenario B: A high school student is working on an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.

Scenario A

Scenario B

Decision Task 4/30

Question 4

Target Scenario:

A student at a large university is conducting research on the U.S. Electoral College. The student has identified the search terms that she will use in her search for information, and discovers that there are several perspectives on the topic. She needs to determine the approach she would like to take in her research, whether she will present a case in support of the Electoral College system, or against it.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A physician in a large hospital is putting together a treatment plan for a patient with colon cancer. The physician has determined a number of promising options, including naturopathic options. She would like to make a request to the hospital board for an increase in funding for naturopathic treatment options, but is having trouble putting together the proposal. She is uncertain of the specific treatments she wants to include in the proposal, and the sort of evidence she would need to make a strong case for each.

Scenario B: A friend in the neighborhood received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She would like to find out more about ocean variability, volcanic activity, and solar output within the last decade, to include in her message.

Scenario A

Scenario B

Decision Task 5/30
Question 5

Target Scenario:

A student enrolled in a political science course at a large university is conducting research on the U.S. Electoral College. The student identified the search terms that she will use in her search for information on her topic, and finds a number of book and article titles appearing in a search results list. She is uncertain about how to find each item on the list.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: An elementary school student is working on an assignment for a unit on future careers. The library teacher asks her to list the kinds of questions she wants to address, and the information she will need to address them. The student explains that she will be making a presentation to the class on a career in law enforcement, and is thinking about focusing on either the kinds of training necessary or the types of related jobs that are available.

Scenario B: A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the end of the article.

Scenario A

Scenario B

Decision Task 6/30

Question 6

Target Scenario:

A student at a large university is in the campus library conducting research on the U.S. Electoral College. The student has identified the search terms that she has used for her search, and points out a number of book and article titles appearing in a search results list. The student is uncertain about how to determine the point of view in each.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: An acquaintance in the neighborhood mentions receiving an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She is also unfamiliar with the organization that sent her the email message, and would like to find out more about this organization before sending the message.

Scenario B: A physician's assistant in a large hospital is putting together a treatment plan for a patient with colon cancer. She has determined a number of management techniques and would like to provide a reference guide to the patient, but is uncertain about how to find information about each technique and for the numerous side effects related to chemo therapy.

Scenario A

Scenario B

Decision Task 7/30

Question 7

Target Scenario:

A neighbor received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change, a topic she is very much interested in. She is preparing to write an email message to her senator, and is considering the topics she would like to address in her message.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A friend in the neighborhood received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She would like to find out more about ocean variability, volcanic activity, and solar output within the last decade, to include in her message.

Scenario B: A high school student is working on an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to

find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.

Scenario A

Scenario B

Decision Task 8/30

Question 8

Target Scenario:

A friend in the neighborhood received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She would like to find out more about ocean variability, volcanic activity, and solar output within the last decade, to include in her message.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the end of the article.

Scenario B: An acquaintance in the neighborhood mentions receiving an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She is also unfamiliar with the organization that sent her the email message, and would like to find out more about this organization before sending the message.

Scenario A

Scenario B

Decision Task 9/30

Question 9

Target Scenario:

An acquaintance in the neighborhood mentions receiving an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She is also unfamiliar with the organization that sent her the email message, and would like to find out more about this organization before sending the message.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A neighbor received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change, a topic she is very much interested in. She is preparing to write an email message to her senator, and is considering the topics she would like to address in her message.

Scenario B: An elementary school student is working on an assignment for a unit on future careers. The librarian asks her to explain the assignment, and list the kinds of questions she wants to address. The student explains that she will be making a presentation to the class on a career in law enforcement. She has found several websites related to law enforcement training, career paths, and salaries, but some seem to be recruiters and others are blogs clearly critical of law enforcement.

Scenario A

Scenario B

Decision Task 10/30

Question 10

Target Scenario:

An elementary school student is working on an assignment for a unit on future careers. The library teacher asks her to list the kinds of questions she wants to address, and the information she will need to address them. The student explains that she will be making a presentation to the class on a career in law enforcement, and is thinking about focusing on either the kinds of training necessary or the types of related jobs that are available.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A student enrolled in a political science course at a large university is conducting research on the U.S. Electoral College. The student identified the search terms that she will use in her search for information on her topic, and finds a number of book and article titles appearing in a search results list. She is uncertain about how to find each item on the list.

Scenario B: An elementary school student is working on an assignment for a unit on future careers. The librarian asks her to explain the assignment, and list the kinds of questions she wants to address. The student explains that she will be making a presentation to the class on a career in law enforcement. She has found several websites related to law enforcement training, career paths, and salaries, but some seem to be recruiters and others are blogs clearly critical of law enforcement.

Scenario A

Scenario B

Decision Task 11/30

Question 11

Target Scenario:

A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She

decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the end of the article.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A high school student is working on an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.

Scenario B: An oncologist in a large hospital is putting together a treatment plan for a patient with colon cancer. The oncologist has determined a number of management techniques. The patient has asked her to recommend naturopathic treatments as possible options, but the oncologist is unfamiliar with these options. The oncologist has compiled a number of sources describing clinical trials of promising naturopathic treatments, but she is uncertain about the reliability of these sources.

Scenario A

Scenario B

Decision Task 12/30

Question 12

Target Scenario:

A high school student needs help with her world history class assignment. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student decides to find out more about the Holocaust, and finds a long list of websites related to the Holocaust. She discovers that some of the websites are posted by groups that deny the Holocaust actually occurred, and is skeptical of the others.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: An elementary school student is working on an assignment for a unit on future careers. The library teacher asks her to list the kinds of questions she wants to address, and the information she will need to address them. The student explains that she will be making a presentation to the class on a career in law enforcement, and is thinking about focusing on either the kinds of training necessary or the types of related jobs that are available.

Scenario B: A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the end of the article.

Scenario A

Scenario B

Decision Task 13/30

Question 13

Target Scenario:

A physician in a large hospital is putting together a treatment plan for a patient with colon cancer. The physician has determined a number of promising options, including naturopathic options. She would like to make a request to the hospital board for an increase in funding for naturopathic treatment options, but is having trouble putting together the proposal. She is uncertain of the specific treatments she wants to include in the proposal, and the sort of evidence she would need to make a strong case for each.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A high school student needs help with her world history class assignment. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student decides to find out more about the Holocaust, and finds a long list of websites related to the Holocaust. She discovers that some of the websites are posted by groups that deny the Holocaust actually occurred, and is skeptical of the others.

Scenario B: A neighbor received an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is before Congress related to climate change, a topic she is very much interested in. She is preparing to write an email message to her senator, and is considering the topics she would like to address in her message.

Scenario A

Scenario B

Logic destination

Question 14: Target Scenario: An elemen...

Decision Task 14/30

Question 14

Target Scenario:

An elementary school student is working on an assignment for a unit on future careers. The student explains to the librarian that she will be making a presentation to the class on a career in law enforcement, and will cover the kinds of training necessary, the types of related jobs that are available, and the average salary for these jobs. She is frustrated by finding only one outdated book in the library related to law enforcement.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A physician's assistant in a large hospital is putting together a treatment plan for a patient with colon cancer. She has determined a number of management techniques and would like to provide a reference guide to the patient, but is uncertain about how to find information about each technique and for the numerous side effects related to chemo therapy.

Scenario B: An acquaintance in the neighborhood mentions receiving an email message with background information and a request to write to her senator in support of a U.S. Senate bill that is

before Congress related to climate change. She is interested in the topic and would like to send a message to her senator, but does not know much about the particular Senate bill. She is also unfamiliar with the organization that sent her the email message, and would like to find out more about this organization before sending the message.

Scenario A

Scenario B

Decision Task 15/30

Question 15

Target Scenario:

An elementary school student is working on an assignment for a unit on future careers. The librarian asks her to explain the assignment, and list the kinds of questions she wants to address. The student explains that she will be making a presentation to the class on a career in law enforcement. She has found several websites related to law enforcement training, career paths, and salaries, but some seem to be recruiters and others are blogs clearly critical of law enforcement.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A high school student is working on an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.

Scenario B: An oncologist in a large hospital is putting together a treatment plan for a patient with colon cancer. The oncologist has determined a number of management techniques. The patient has asked her to recommend naturopathic treatments as possible options, but the oncologist is unfamiliar with these options. The oncologist has compiled a number of sources describing clinical trials of promising naturopathic treatments, but she is uncertain about the reliability of these sources.

Scenario A

Scenario B

Decision Task 16/30

Question 16

Target Scenario:

A student at a large university is conducting research on the U.S. Electoral College. The student has identified the search terms that she will use in her search for information, and discovers that there are several perspectives on the topic. She needs to determine the approach she would like to take in her research, whether she will present a case in support of the Electoral College system, or against it.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: An elementary school student is working on an assignment for a unit on future careers. The library teacher asks her to list the kinds of questions she wants to address, and the information she will need to address them. The student explains that she will be making a presentation to the class on a career in law enforcement, and is thinking about focusing on either the kinds of training necessary or the types of related jobs that are available.

Scenario B: A student at a large university is in the campus library conducting research on the U.S. Electoral College. The student has identified the search terms that she has used for her search, and points out a number of book and article titles appearing in a search results list. The student is uncertain about how to determine the point of view in each.

Scenario A

Scenario B

Decision Task 17/30

Question 17

Target Scenario:

A high school student is working on an assignment in the school library for her world history class. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the Holocaust, but is having a hard time using the article index and the reference list links at the end of the article.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A high school student is working on an assignment for a world history class. The teacher requires her to do a slideshow presentation on the legacy of one World War II era event. The student does not know much about World War II, and looks at the related Wikipedia article. She decides to find out more about the crash of the Hindenburg, the Holocaust, and the bombing of Hiroshima and Nagasaki.

Scenario B: A student enrolled in a political science course at a large university is conducting research on the U.S. Electoral College. The student identified the search terms that she will use in her search for information on her topic, and finds a number of book and article titles appearing in a search results list. She is uncertain about how to find each item on the list.

Scenario A

Scenario B

Decision Task 18/30

Question 18

Target Scenario:

An oncologist in a large hospital is putting together a treatment plan for a patient with colon cancer. The oncologist has determined a number of management techniques. The patient has asked her to recommend naturopathic treatments as possible options, but the oncologist is unfamiliar with these

options. The oncologist has compiled a number of sources describing clinical trials of promising naturopathic treatments, but she is uncertain about the reliability of these sources.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A high school student needs help with her world history class assignment. The teacher requires her to do a slideshow presentation on the legacy of a World War II era event. The student decides to find out more about the Holocaust, and finds a long list of websites related to the Holocaust. She discovers that some of the websites are posted by groups that deny the Holocaust actually occurred, and is skeptical of the others.

Scenario B: A physician's assistant in a large hospital is putting together a treatment plan for a patient with colon cancer. She has determined a number of management techniques and would like to provide a reference guide to the patient, but is uncertain about how to find information about each technique and for the numerous side effects related to chemo therapy.

Scenario A

Scenario B

Decision Task 19/30

Question 19

Target Scenario:

You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find an accommodation in an appealing neighborhood. You have never traveled abroad before, and are uncertain over what you need to know before making a decision that will affect your enjoyment of the trip.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over how to begin the process of securing financing. You consider the kinds of questions you need to ask, and the places you need to go to find out more.

Scenario B: You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find out more about accommodations in two appealing neighborhoods recommended to you by friends.

Scenario A

Scenario B

Decision Task 20/30

Question 20

Target Scenario:

After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. Your real estate agent has asked you to determine the amount of financing for which you are pre-approved, but you are not sure of how to approach the lending sources you have identified.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over how to begin the process of securing financing. You consider the kinds of questions you need to ask, and the places you need to go to find out more.

Scenario B: Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over which make and model will best suit your driving needs and the amount you are willing to spend. A friend recommends an online auto review site, but you are unfamiliar with the website and how to get the information you need from it.

Scenario A

Scenario B

Decision Task 21/30

Question 21

Target Scenario:

You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, but have determined two appealing neighborhoods based upon your research. You have identified two accommodations that interest you: one recommended by a work colleague, and one recommended by an online travel advisory website. You need to find a way to evaluate these recommendations before making your choice.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, and have determined your driving needs and the amount you are willing to spend. You have identified three different vehicles that appear to suit your needs: one recommended by an online auto review website, one recommended in an online auto blog, and one recommended by a family friend. You are uncertain over which one to choose.

Scenario B: You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find out more about accommodations in two appealing neighborhoods recommended to you by friends.

Scenario A

Scenario B

Decision Task 22/30

Question 22

Target Scenario:

Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over your needs and which make and model will best suit them. You think about the amount you are willing to spend and the type of driving you expect to do, but still feel overwhelmed about how to begin the process.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, and have determined your driving needs and the amount you are willing to spend. You have identified three different vehicles that appear to suit your needs: one recommended by an online auto review website, one recommended in an online auto blog, and one recommended by a family friend. You are uncertain over which one to choose.

Scenario B: You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find an accommodation in an appealing neighborhood. You have never traveled abroad before, and are uncertain over what you need to know before making a decision that will affect your enjoyment of the trip.

Scenario A

Scenario B

Decision Task 23/30

Question 23

Target Scenario:

You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, and not sure how to find out more about accommodations in two appealing neighborhoods recommended to you by friends.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. Your real estate agent has asked you to determine the amount of financing for which you are pre-approved, but you are not sure of how to approach the lending sources you have identified.

Scenario B: You have purchased airfare for travel to a foreign country during the summer, and need to find accommodations. You have never been to Paris, France before, but have determined two appealing neighborhoods based upon your research. You have identified two accommodations that interest you: one recommended by a work colleague, and one recommended by an online travel advisory website. You need to find a way to evaluate these recommendations before making your choice.

Scenario A

Scenario B

Decision Task 24/30

Question 24

Target Scenario:

Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, and have determined your driving needs and the amount you are willing to spend. You have identified three different vehicles that appear to suit your needs: one recommended by an online auto review website, one recommended in an online auto blog, and one recommended by a family friend. You are uncertain over which one to choose.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: Your old car has just broken down, and you need to purchase a new one. You have decided to buy a brand-new vehicle, but are uncertain over your needs and which make and model will best suit them. You think about the amount you are willing to spend and the type of driving you expect to do, but still feel overwhelmed about how to begin the process.

Scenario B: After working in a new job for a year, your rental lease is up and you have decided to purchase a new condominium unit, but need to explore ways to finance it. You are unfamiliar with housing costs in the new city in which you live, and uncertain over the financing process. You have approached two lending sources to determine a pre-approval amount, but have received two very different figures. You are uncertain over how to decide which offer to take.

Scenario A

Scenario B

Decision Task 25/30

Question 25

Target Scenario:

A college dean claims that good readers earn better grades than poor readers. The grade point averages (GPA) are recorded for 50 first-year students who scored high on a reading comprehension test and for 50 first-year students who scored low on a reading comprehension test.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A college dean claims that scores on a reading comprehension test predict college grades. The grade point averages (GPA) and reading comprehension scores are recorded for 100 first-year students.

Scenario B: A psychologist tests the hypothesis that fatigue affects mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the

psychologist records the number of errors for each subject. Two groups of subjects are selected. The first group of 10 subjects is tested after they have been kept awake for 24 hours. The second group of 10 subjects is tested in the morning after a full night's sleep.

Scenario A

Scenario B

Decision Task 26/30

Question 26

Target Scenario:

A psychologist tests the hypothesis that people who are fatigued also lack mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are selected; half are tested after being kept awake for 24 hours, and half are tested in the morning after a full night's sleep. Based on their number of errors on the test, each subject is also labeled as high or low in mental alertness.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A personnel expert wishes to determine whether or not experienced typists are likely to be fast typists and inexperienced typists are more likely to be slow typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Based on the test, each typist is classified as fast or slow.

Scenario B: A psychologist tests the hypothesis that fatigue is related to mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are given this test, each with a different number of hours since they woke up (ranging from 1 to 20).

Scenario A

Scenario B

Decision Task 27/30

Question 27

Target Scenario:

A college dean claims that scores on a reading comprehension test predict college grades. The grade point averages (GPA) and reading comprehension scores are recorded for 100 first-year students.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A college dean claims that a group of good readers contains more honors students than a group of poor readers. For each of 100 first-year college students, a reading comprehension test was used to determine whether the student was a good or poor reader and grade point average (GPA) was used to determine whether or not the student was an honors student.

Scenario B: A personnel expert wishes to determine whether typing experience goes with faster typing speeds. Forty typists are asked to report how many years they have worked as typists and are given a typing test to determine their average number of words typed per minute.

Scenario A

Scenario B

Decision Task 28/30

Question 28

Target Scenario:

A personnel expert wishes to determine whether experienced typists are able to type faster than inexperienced typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Each typist's average number of words typed per minute is recorded.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A college dean claims that good readers earn better grades than poor readers. The grade point averages (GPA) are recorded for 50 first-year students who scored high on a reading comprehension test and for 50 first-year students who scored low on a reading comprehension test.

Scenario B: A personnel expert wishes to determine whether or not experienced typists are likely to be fast typists and inexperienced typists are more likely to be slow typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Based on the test, each typist is classified as fast or slow.

Scenario A

Scenario B

Decision Task 29/30

Question 29

Target Scenario:

A college dean claims that a group of good readers contains more honors students than a group of poor readers. For each of 100 first-year college students, a reading comprehension test was used to determine whether the student was a good or poor reader and grade point average (GPA) was used to determine whether or not the student was an honors student.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A college dean claims that scores on a reading comprehension test predict college grades. The grade point averages (GPA) and reading comprehension scores are recorded for 100 first-year students.

Scenario B: A psychologist tests the hypothesis that people who are fatigued also lack mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are selected; half are tested after being kept awake for 24 hours, and half are tested in the morning after a full night's sleep. Based on their number of errors on the test, each subject is also labeled as high or low in mental alertness.

Scenario A

Scenario B

Decision Task 30/30

Question 30

Target Scenario:

A personnel expert wishes to determine whether typing experience goes with faster typing speeds. Forty typists are asked to report how many years they have worked as typists and are given a typing test to determine their average number of words typed per minute.

Which of the following scenarios below goes best with the target scenario above?

Scenario A: A psychologist tests the hypothesis that fatigue is related to mental alertness. An attention test is prepared which requires subjects to sit in front of a blank TV screen and press a response button each time a dot appears on the screen. A total of 110 dots are presented during a 90-minute period, and the psychologist records the number of errors for each subject. Twenty subjects are given this test, each with a different number of hours since they woke up (ranging from 1 to 20).

Scenario B: A personnel expert wishes to determine whether experienced typists are able to type faster than inexperienced typists. Twenty experienced typists (i.e., with 5 or more years of experience) and 20 inexperienced typists (i.e., with less than 5 years of experience) are given a typing test. Each typist's average number of words typed per minute is recorded.

Scenario A

Scenario B

Appendix D: Catalyst Tool Summary Description

The screenshot shows the Catalyst Tool interface for a survey titled "Sorting Information Problems". The user is identified as JOHN L JR MARINO (marinoj) and is using the WebQ tool. The interface is divided into several sections:

- Summary** (selected), Build, Results, Preview
- Security, Notifications, & Publishing**
 - Security: Anyone
 - Availability: Open: 10/03/2015 8:25:07 AM PDT, Close: 5/14/2016 12:20:38 PM PDT
 - Collaboration:
- Settings**
 - Participant experience: Display confirmation code, Display custom content
 - Results notification: Daily
 - Survey appearance: Custom numbering
 - Contact info: John Marino, marinoj@uw.edu
- About this Confidential Research Survey**
 - Actions: Rename, Copy, Copy to another account, Delete
 - URL: https://catalyst.uw.edu/webq/survey/marinoj/269252
 - Owner: JOHN L JR MARINO
 - Published: No
 - Submissions: 212 current, 223 total
 - Created: 4/26/2015 8:59:24 AM PDT
 - Last modified: 5/14/2016 12:20:39 PM PDT
 - Questions: 43

Appendix E: Participant Description Survey

Thank you for completing the decision tasks!

Please answer the following demographic information questions to enable analysis of decision task responses.

Demographic Question 1/7

Question 31

What is your age?

- 18-25 years
- 26-35 years
- 36-45 years
- 46-55 years
- 56 or more years

Demographic Question 2/7

Question 32

What is your gender?

- Female
- Male
- Other:

Demographic Question 3/7

Question 33

What is your highest level of education?

- High school diploma or equivalent

- Bachelor's degree
- Master's degree
- PhD

Demographic Question 4/7

Question 34

How would you describe your English language fluency?

- Fluent: English is my primary language or I am bilingual
- Developing fluency: English is my second language
- Not fluent: I am learning English

Demographic Question 5/7

Question 35

How would you describe your experience in the field of librarianship?

- No experience: I have never taken a course related to librarianship, nor have I worked in the field
- Some experience: I have taken one or more courses related to librarianship, or I have worked in the field
- Experienced: I have completed a graduate degree in library and information science (or equivalent), and I have worked in the field for less than 10 years
- Very Experienced: I have completed a graduate degree in library and information science (or equivalent), and I have worked in the field for 10 years or more

Demographic Question 5A/7

Question 36

Which best describes the setting for your work experience in librarianship?

- Public library
- K-12 school library
- Academic library
- Corporate library
- Other:

Demographic Question 6/7

Question 37

How would you describe your experience in the field of statistics?

- No experience: I have never taken a course related to statistics, nor have I worked in the field
- Some experience: I have taken one or more courses related to statistics, or I have worked in the field
- Experienced: I have earned a graduate degree in statistics, and I have worked in the field for less than 10 years
- Very Experienced: I have earned a graduate degree in statistics, and I have worked in the field for 10 years or more

Demographic Question 7/7

Question 38

Based on your own understanding of information literacy, how would describe your level of information literacy?

- Not very information literate
- Somewhat information literate

- Reasonably information literate
- Very information literate

Research Activity Request
Question 39

If you would be willing to participate in a follow up research activity, please enter a contact email address in the box below.

If you choose to participate in this research activity, you will meet with a researcher on the University of Washington campus or other public location convenient to you (public library, Starbucks coffee shop, etc.), and complete a categorizing activity. In each round of this categorizing activity, you will be asked to randomly select three brief scenarios from a stack and describe how two of the three are similar to one another and how they are different from the third scenario. You will be asked to complete approximately 12 rounds, and the estimated time for completion is 30 minutes. As an acknowledgment of your time for participation in this research activity, you will receive a \$30 gift certificate.

Entry for Gift Certificate Drawing
Question 40

If you would like to be entered in a random drawing for a \$50 gift certificate, please enter a contact email address in the box below.

One \$50 gift certificate will be provided for every 50 participants (up to a total of 5 gift certificates) within one week after data has been collected.

Appendix F: Recruitment Messages

Investigation 1, Message 1: Face-to-Face Class Pitch (targeted novice group):

- I am a PhD candidate in the iSchool and library teacher
- I am working with Mike Eisenberg, my advisor and Dean Emeritus of the iSchool
- I need your help: libraries, school programs, search engines good at locating info, but not good at helping us solve problems
- I am conducting a study to better understand how we solve information problems to improve library support, school programs, and info systems
- Online, sorting problems, takes about 30 minutes
- \$50 Amazon gift card drawing for every 10 people
- Either link: tinyurl.com/problemsort or catalyst.uw.edu/webq/survey/marinoj/269252
- Thank you!

Investigation 1, Message 2: Email Message (targeted novice group):

Greetings!

I am a PhD candidate in the Information School, and a teacher-librarian in the Lake Washington School District. I am working with my advisor Mike Eisenberg, dean and professor emeritus of the iSchool.

We need your help! Libraries, search engines, and schools are good at providing information and teaching us how to locate it, but not very good at helping us to solve problems. We are conducting a study to better understand how we solve information problems to improve library support, information systems, and school programs.

Participation is easy. Just go online (<http://tinyurl.com/problemsort>) and sort a series of problems; you are encouraged to move quickly through the decision tasks, and completion should take less than 30 minutes. Completion of all decision tasks enters you in a drawing for a \$50 Amazon gift card; a gift card will be awarded for every 10 participants.

Here is the link:

<http://tinyurl.com/problemsort>

Note: Scenarios are best viewed with **Firefox or Google Chrome** browsers.

Thank you!

John Marino
PhD Candidate
iSchool/UW
(contact information here)

Mike Eisenberg
Dean and Professor Emeritus
Information School/UW

Investigation 1, Message 3: Email Message (targeted expert group):

Greetings!

I am a librarian in the Lake Washington School District and PhD candidate in the Information School at the University of Washington. I am working with my advisor Mike Eisenberg, dean and professor emeritus.

PLEASE - we need your help! In order to improve services and programs, I am seeking to better understand how experienced professionals in our field solve information problems. We hope that your participation in this study will clarify the value of “thinking like a librarian.” This research will provide insights on how to better serve and meet patrons' needs.

Participation is easy and relatively short (less than 30 minutes). Just go online (tinyurl.com/problemsort). You will be given a set of problems and scenarios to analyze and choose from 2 decision options. From our pre-test, we know that you should move quickly through the decision tasks. Again, completion should take less than 30 minutes. Participation and completion of the entire exercise enters you in a drawing for one of several \$50 Amazon gift cards.

Here again is the link:

tinyurl.com/problemsort

Note: Scenarios are best viewed with **Firefox or Google Chrome** browsers.

Thank you!

John Marino
PhD Candidate
iSchool/UW
(*contact information here*)

Mike Eisenberg
Dean and Professor Emeritus
Information School/UW

Investigation 2, Message 1: Email Message (targeted novice group)

Subject: Research Participation + 20 Minutes = \$30 Gift Card

Hello!

Last fall you participated in an online research study through the University of Washington. This study seeks to better understand how we solve information problems to improve library support, information systems, and school programs.

You indicated an interest in participating in a brief 20-minute follow-up activity where you will receive a \$30 Amazon gift card as an acknowledgment of your time.

If you choose to participate in this follow-up research activity, you will meet with a researcher on the University of Washington campus or other public location convenient to you (public library, coffee shop, etc.) and complete a categorizing activity. In each round of this categorizing activity, you will be asked to randomly select three brief scenarios from a stack and describe how two of the three are similar to one another, and how they are different from the third scenario. You will be asked to complete 11 rounds, and the estimated time for completion is 20 minutes.

Please contact me at your earliest convenience to set up an appointment if you choose to participate in this follow-up research activity.

Thank you!

John Marino
PhD Candidate
Information School/UW
(*contact information here*)

Investigation 2, Message 2: Email Message (targeted expert group)

Subject: Request for UW Research Follow-Up Participation

Hello!

Recently, you participated in an online research study through the University of Washington. This study seeks to better understand how we solve information problems to improve library support, information systems, and school programs. We thank you for completing the scenario sorting tasks, and indicating an interest in participating in a follow-up research activity.

If you choose to participate in this follow-up research activity, you will meet with a researcher at a public location convenient to you (public library, coffee shop, etc.) and complete a categorizing activity. In each round of this categorizing activity, you will be asked to randomly select three brief scenarios from a stack and describe how two of the three are similar to one another, and how they are different from the third scenario. You will be asked to complete 11 rounds, and the estimated time for completion is 20 minutes. As an acknowledgment of your time for participation in this research activity, you will receive a \$30 Amazon gift card.

Please contact me at your earliest convenience to set up an appointment if you choose to participate in this follow-up research activity.

Thank you!

John Marino
PhD Candidate
Information School/UW
(contact information here)

Appendix G: Investigation 2 RepGrid Sorting Task Protocol

UNIVERSITY OF WASHINGTON PARTICIPANT INFORMATION SHEET

CATEGORIZING INFORMATION PROBLEMS

The following principal investigator is studying information behavior, focusing on the way people embark on solving information problems at school, work, and in their everyday lives:

John L. Marino, Jr., Doctoral Candidate, Information School, University of Washington,
marinoj@uw.edu, 206-271-7691

Researchers' statement

The purpose of this section is to give you the information you will need to help you decide whether to be in this research study or not. Please read this information carefully. You may ask questions about the purpose of the research, what you are being asked to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this section that is not clear. You are completely free to decide if you want to be in this study or not. This process is called "informed consent." This Participant Information Sheet is for your records.

PURPOSE OF THE STUDY

This is a study of information behavior, with a focus on the way people solve problems or manage situations in which further information is needed. In this study, these problems or

situations are called information problems. Typically, when individuals encounter information problems in their work or everyday lives, they embark on a process called information problem-solving. The purpose of this study is to examine the way that individuals categorize information problems in a variety of situations.

STUDY PROCEDURES

If you choose to participate in this study, you will meet with a researcher on the University of Washington campus or other public location convenient to you (public library, Starbucks coffee shop, etc.), and complete a categorizing activity. In each round of this categorizing activity, you will be asked to randomly select three brief scenarios from a stack and describe how two of the three are similar to one another and how they are different from the third scenario. You will be asked to complete approximately 12 rounds, and the estimated time for completion is 30 minutes.

You may refuse to answer any question and end your participation in the study at any time.

RISKS, STRESS, OR DISCOMFORT

We do not anticipate any risks or discomfort to you from your participation in this study. Any data collected from you in this study will be anonymous. However, summarized data and anonymized excerpts from research activities may be published in research reports and presentations. You may refuse to participate or withdraw from the study at any time.

It is important that you promptly tell the lead researcher if you believe that you have been harmed because of taking part in this study. You can tell the researcher in person or call the number listed. This number is monitored 24 hours a day.

The UW does not normally provide compensation for harm except through its discretionary program for medical injury. However, the law may allow you to seek other compensation if the harm is the fault of the researcher. You do not waive any right to seek payment by agreeing to participate in this study.

BENEFITS OF THE STUDY

You may not directly benefit from taking part in this study. As an acknowledgment of your time for participation in this research activity, you will receive a \$30 gift certificate. Your participation in the study, however, may contribute to a better understanding of human information behavior, suggest improvements for the design of information systems and services, and guide the development of educational programs to improve information problem-solving skills in schools, work environments, and everyday life.

CONFIDENTIALITY OF RESEARCH INFORMATION

Data collected for this study will be anonymous. Your responses will be identified by randomly-generated codes. Any contact information you provide for the random drawing or for participating in the follow up research activity will not be connected to your research data in any way and will be kept confidential.

OTHER INFORMATION

You may refuse to participate and you are free to withdraw from this study at any time without penalty or loss of benefits to which you are otherwise entitled.

AGREEMENT

By agreeing to participate in this research activity, you acknowledge that the purpose and nature of this research have been sufficiently explained to you. You also acknowledge that you are over 18 years old, and understand that you are free to withdraw at any time without incurring any penalty.

RepGrid Sorting Task Procedures

1. Welcome participant and ask to complete the informed consent process.

“Hello! My name is John Marino. Thank you for responding to my request for participation in this follow-up interview to the online survey you completed earlier.

This study investigates the way people embark upon solving problems or managing situations in which more information is needed. I will ask you to sort sets of scenario cards, and explain your reasoning. There are several sets, and the entire process shouldn't take more than 30 minutes. I'd like to thank you for your time with an Amazon gift card. You may refuse to answer any question and end your participation in the study at any time.

Before agreeing to participate in this follow-up interview, please read over the Participant Information Sheet and let me know if you have any questions and if you would like to continue to participate.”

2. Participants agreeing to participate will then be asked to initiate the RepGrid sorting tasks for Set 1 (domain of librarianship).

“Do you have any questions? OK, let's begin. I will ask you to pick any three cards from a stack. You are to read the scenarios, and decide which two are more similar than the third. I will ask you to tell me a way in which two scenarios are similar to each other and different from the third. There is no right or wrong grouping, so group them in whichever way makes sense to you.

Go ahead and pick any 3 scenario cards from this stack (Set 1), read them, and group two that are more similar than the third. (*Wait for grouping.*)

Why are these two similar? (*Wait for response.*)

What are they different from the third? (*After response, begin laddering process.*)

- Tell me what you mean by...
- Give me an example of...
- How would one recognize this characteristic of...
- Is there a particular important aspect of...
- How do you know...
- In which way is it different...
- What evidence can you give...

(Record constructs, then scenario card identification numbers. Repeat until construct pattern emerges.)

3. Then initiate the RepGrid sorting tasks for Sets 2-3 (domains of everyday life and statistics).

OK, now I will ask you to pick from a stack with different scenarios. Go ahead and pick any 3 scenario cards from this stack (Set 2), read them, and group two that are more similar than the third. *(Wait for grouping.)*

Why are these two similar? *(Wait for response.)*

What are they different from the third? *(After response, begin laddering process.)*

- Tell me what you mean by...
- Give me an example of...
- How would one recognize this characteristic of...
- Is there a particular important aspect of...
- How do you know...
- In which way is it different...
- What evidence can you give...

(Record constructs, then scenario card identification numbers. Repeat until construct pattern emerges.)

4. Participants completing all tasks will be acknowledged for their time and presented with a \$30 Amazon gift card.

Well, that's all! I greatly appreciate your participation in this study, and am happy to thank you for your time with this Amazon gift card. If you have any questions about the study, my contact information is on the Participant Information Sheet. Thank you again!

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