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Exploring Information Use Behavior in the Context of Knowledge Construction

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Abstract

The study focuses on a task-driven context to investigate two issues, including "informants' information use behavior in a learning context" and "how the knowledge structure has changed after utilizing the information". Qualitative methods were employed in this study, including observation, in-depth interview, and document analysis. One of the authors entered the setting as an observer-as-participant to observe the interaction between the lecturer and participants. Semi-structured interviews were conducted to better understand informants' information use behavior and their cognition toward major concepts of the learning topic.

Knowledge construction commenced with evaluating learning tasks assigned by lecturer, examining knowledge structure, deciding the ways of processing information, and then putting into action. During the process, the participants used information in different manners, including browsing, examining, re-examining, marking up, extracting, translating, reconstructing or setting aside. Findings indicate that information use behavior varied in different tasks, and knowledge structures were mainly expanded based on prior knowledge. Several factors influence information use behavior, such as the importance of learning tasks, different forms of knowledge representation, and the time limit, which are the key facts influencing how the information will be used.

Keywords: Information Use; Information Behavior; Knowledge Construction; Knowledge Representation

1. Introduction

The earliest study of information behavior can be dated back to the 1940s. Since then, theoretical and empirical issues have attracted researchers from both academic and practitioner communities to devote their efforts into researches. The researchers tried to take different approaches to reveal the essence of information-behavior, such as information needs, information seeking behavior, and information selection.

Even with the significant amount of information behavior studies, there has been limited number of researches revealing the insights of how users utilize information from various resources, and what impact of information is made to one's knowledge structure. The majority of studies focus on either how users obtain information needed, such as work done by Martyn (1974), or how users manage and reason information acquire (Spink & Cole, 2006). Kenny (2008) further stated that the great number of information behavior related studies focused

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on [information] seeking by reproducing an exercise conducted by Kari (2007). Kenny (2008) conducted a search of the peer-reviewed literature in the database *Library and Information Science Abstracts* (*LISA*). The search term "information needs" produced 1,208 results (1,156 hits in Kari's study) and "information seeking" produced 1,113 results (1,006 references in Kari's). However, "information use" only yielded 171 hits (157 publications in Kari's). The aforementioned numbers produced by Kenny were only slightly increased compared to the ones in Kari's study, while the all figures were still in the same proportion. Kenny (2008, p. 3) kept on saying that numerous researchers had been discussing about the gap and imbalance in the research literature (Kari, 2007; Savolainen, 2006; Spink & Cole, 2006; Todd, 1999; Vakkari, 1997), and that the calling for increased empirical research on information use study is a cliché. Hence, the need for investigating information user behavior from various perspectives remains.

Due to the gap in literature, the authors' aims are to reveal the information use behavior by relating participants' knowledge structure in the process of making sensing information. The study of information use behavior does not only refer to the investigation of used sources and channels, but the relation between the participants and the information. The authors strive to investigate that if knowledge structure of each actor could lead to different ways of information use. In order to verify and explore the relationship between knowledge structure and information use behavior, the purpose of this study is to investigate two issues for the processes of information use that are left within a 'black box' (Savolainen, 2006, p. 1116) in terms of knowledge construction: (1) how students use information obtained and (2) how the knowledge structure changed after using the information. The authors tend to provide a clearer picture of information use behavior in a leaning environment and to serve as a reference for information providers by answering the research questions above.

2. Literature Review

2.1 Information use

Even though the number of researches in information use is limited comparing to other researches related to information behavior, information use is always one of the concerned issues in information behavior studies. In the 1970s, information use related researches were focused on how users acquired information they needed, and how the information obtained was disseminated (Allen, 1969; Martyn, 1974; Menzel, 1966). Two main streams of information use study have been developed since the 1980s, namely comprehending and instrumental elements (Caplan, 1980; Spink & Cole, 2006; Wilson, 2000), which denoted that users would manage to understand information cognitively. Once information has effect on user's knowledge structure, users may put it into use according to the information they learned.

Vakkari (1997) pointed out that information use behavior should be examined both in comprehending and instrumental ways. Research should not only focus on how the information was acquired to solve problems or accomplish tasks, but also investigate the impact of information used on one's knowledge structure. Dervin (1999) asserted that people would use information when

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confronting discontinuity, which manifests itself as a gap between external and internal worlds. The whole process of gap-bridging can be termed as sense-making. Savolainen (2006, p. 1117) claimed that "the metaphor of gap-bridging is an integral part of the metaphorical triangle of situation-gap-uses in that gap-bridging stands for the process which resulted in various outcomes of information seeking and use." One of the barriers to investigate information use is the inability to understand what's on people's mind, so that whether the information has been used or not remains unknown. In our study, we present the informants' information use behavior by relating to their knowledge structure. According to Todd (2006), "learning is perceived as a process of personal and social construction where people are actively involved in making sense of information they interact with." Information use behavior would be therefore better examined in a learning setting.

Dervin (1983, p. 3) proposed that "information seeking and use is central to sense-making," and further stated that knowledge gap could be filled by using information. The current study aims to explore information use by employing sense-making framework which manifests the theoretical construct of the theory- Situation-Gap-Use. Current Sense-Making model centers on the time-space context at which sense is constructed and users might confront information needs which will make them bridge the gap and move through time-space, thus users will construct their own world by using information. This metaphor constructs the sense-making triangle of situation-gap-use/help and further develops a pictorial sense-making metaphor which depicts the steps that users will take at the moment of confronting discontinuity and how users interpret the gap and to bridge the gap and move forward.

Several empirical studies have been conducted to reveal information use behavior in the context of learning environment. Todd (1999) investigated high school students' cognitive changes by reviewing the perceived effects of exposures of heroin information in three stages on four adolescent girls' knowledge structures. The major cognitive activities have been found: get a complete picture, get a changed picture, get a verified picture, get a clearer picture, and get a position in a picture. With regard to the knowledge structure, the above five status could be generalized into appending, inserting, and deleting. In 2006, Todd further investigated the process of converting information into knowledge by examining students' substance of knowledge, amount of knowledge, structure of knowledge, label of knowledge, and the estimate of extent of knowledge. All the data were intertwined and further analyzed, ultimately the changes of knowledge structure were found mainly additive and integrative.

Chung (2003) employed concept maps and interviews to investigate changes in high school students' understanding based on their use of information by reviewing the whole information behavior while performing required learning tasks. The findings show that the students would select, organize, integrate, gather, and use information. Patterns of change in students' concepts and ideas were discovered, including simple, analytical, organizational, and holistic change. Furthermore, Chung revealed the levels of information use by discussing the cognitive activities for achieving meaningful learning. Besides the lower levels

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of learning - "remember" and "understand", the higher levels of learning were also identified - "apply," "analyze," "evaluate," and "create". In addition, the highest level of learning "create" was discovered to show that students would have preliminary hypotheses, which were expected to be supported via coherent structures that were constructed by obtaining comprehensive information.

2.2 Knowledge construction

Knowledge construction is a purposeful course of action. When the learners are constructing their own knowledge, meaningful contents have been built at the same time. By constructing knowledge, people comprehend certain matters to a greater extent (Perkins, 1986).

Rumelhart and Norman (1981, pp. 38-39) tried to examine the process of knowledge construction in terms of learning. The goal of their study is to "indicate how different forms of learning might be integrated into one conceptualization of the systems that acquire, interpret, and use information." The process of knowledge construction can be classified into three categories: accretion, tuning, and restructuring. Accretion refers to the daily accumulation of new set of information. Tuning refers to the interpretation of new information, which involves more than an addition to current knowledge status. Restructuring is an advanced process of knowledge construction that often occurs when new structures are created for new interpretations of the existing knowledge. Critical mass of information and considerable time and effort could lead to the restructuring.

Nonaka (1994) regards knowledge construction as the conversion of tacit and explicit knowledge, including four modes of knowledge conversion. Figure 1 clearly demonstrates the four possible modes of knowledge creation.

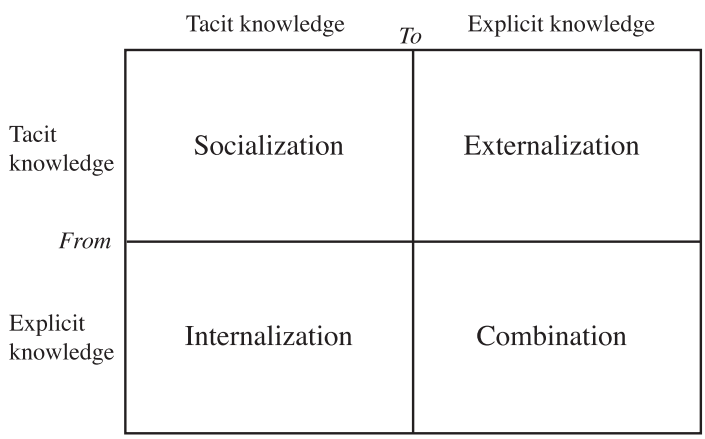


Figure 1. Modes of Knowledge Creation

Note. Adapted from "A Dynamic Theory of Organizational Knowledge Creation," by I. Nonaka, 1994, *Organization Science, 5*(1), p. 19. Copyright 1994 by Institute for Operations Research and the Management Sciences.

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2.3 Knowledge representation

Knowledge representation is not knowledge itself, but a cognitive tool that could support the internalization and externalization of knowledge. The internalization process refers to the objective knowledge being interpreted by individuals from the objective world to the subjective world, whereas the externalization of knowledge transforms subjective inspirations or mental ideas into objective knowledge (Chen & Hung, 2002, p. 281). Generally speaking, "knowledge can be represented visually in different forms; e.g. as a text, picture, figure, diagram and matrix" (Näykki & Järvelä, 2008, p. 361). People could construct their own personalized knowledge representations by communicating the cognitive status after perceiving the aforementioned forms of knowledge representation.

Knowledge representation could reveal one's knowledge structure pertaining to the cognition of the world. Knowledge representation could be analyzed by inference analysis, structural analysis, and discourse analysis, all of which constitute Conceptual Graph Structures. Statement node is the basic unit in Conceptual Graph Structures, the node represents the description of matters that could be subdivided into state, event, goal, and style. Every node could be a new aspect of another node, the whole knowledge structure would be established by connecting all the nodes (Graesser & Clark, 1985, p. 54, 58).

3. Research Design and Data Collection

The study has been conducted in a learning context of a graduate course, to reveal how students applied information in the process of constructing knowledge, and to further investigate the impact of information used on one's knowledge structure by examining the knowledge representation. The setting for this study is a required and advanced course that covers the core issues on information acquisition and organization. As the gatekeeper, the lecturer was willing to offer the course as a setting for this study. Based on a context with knowledge gap, the authors aimed to explore what the subjects would do in order to fill the gap and all the actions were further analyzed to uncover the possible information behavior. One of the authors entered the learning scene as teaching assistant for collecting data and also instructing students on reading the assigned journal articles.

For the purpose of understanding what the subjects think, various outputs were first collected for one semester and examined for additional 6 months, e.g., the answers to the open-ended pre/post-course tests, self-driven learning diaries, all the copies of notes and used printed articles, the interview transcripts, and lastly the observation notes taken by one of the researchers. All the data were analyzed in each category accordingly and then cross validated to ensure the validity of data. The appropriate categories and concepts of the findings were extracted to reveal the results of the study.

3.1 Theory background

The Sense-Making approach, according to Spurgin (2006), is a set of meta-theoretical methodology that suggests methods of framing questions, gathering data, and conducting analyses. The approach is commonly used in the area of information needs and uses. In the studies of information behavior, Dervin (1992) believed that discontinuity exists between reality

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and human sensors, which is consistent with the core conceptual premises of the Sense-Making approach, in which Dervin (1983, p. 4) stated that "reality is neither complete nor constant but rather filled with fundamental and pervasive discontinuities or gaps." Therefore, "information is not a thing that exists independent of and external to human beings but rather is a product of human observing." Dervin (1992) further showed a series of contrasts between traditional assumptions of research approaches and the assumptions of sense-making, which are derived from the aforesaid premises:

First of all, typical research approaches focus on information transmission which declare that information exists apart from human behavioral activity. However, from a sense-making perspective, the use of information itself is constructing, thus "information is conceptualized as that sense created at a specific moment in time-space by one or more humans."

Second, traditional research approaches concentrate on observer's perspective by observing and asking users questions from observer's world instead of users', while a user-oriented approach will center on why the users are communicating with systems from the perspective of actors. The last contrast is discussing the condition that typical and sense-making approach implements. Traditional research approach focuses on states and entities, such as who the user is, what the user has access to, and what skills the user has. Nevertheless, sense-making approach relies on the steps that the user undertakes to construct user's own sense of world.

Current Sense-Making model centers on the time-space context at which sense is constructed and users might confront information needs that will make them bridge the gap and move through time-space. Thus, users will construct their own world by using information. This metaphor constructs the sense-making triangle of situation-gap-use/help and further develops a pictorial sense-making metaphor which depicts the steps that users will take at the moment of discontinuity, the way users interpret the gap, and how to bridge the gap and move forward. The metaphor strongly serves as the fundamental theory framework of the current study, which clearly depicts the overall picture of constructing meaning of perceived objects by using information to bridge the gap and ultimately achieve the goal in the studied class. The proposed research objectives can be therefore fulfilled by applying this solid theory framework.

Sense-making also provides a theory of how to conduct interviews with respondents by implementing four interviewing approaches, including micro-moment time-line interview, abbreviated timeline interview, help chain, and message/q-ing which all focus on different scope of questions in order to have various aspect of answers.

The concept of sense-making developed by Dervin is slightly different from the first articulated notion in 1983 to the ones in 1992 and 2005. "Sense-making" remains a coherent set of concepts and methods in 1992. However, Case (2007, p. 158) pointed out that Dervin (2005, p. 26) regarded "sense-making methodology" as "a theory for methodology" that connects substantive theory and metatheory. Hence, Dervin further developed a theory of the third kind, which could bridge between qualitative and quantitative approaches. Apart from the methodological explication, the method of close-ended interview in 1983 transformed into abbreviated time-line

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interview in 1992, while both hold the same essence.

Also, the focus of sense-making has shifted from the 1980s to 1990s. Dervin (1983, p. 5) supposed "constructing is what is involved in information sharing interactions no matter what the context," and the so called information sharing was conceived of as "the successive modifications of internal pictures of reality- a series of constructings and reconstructings." Dervin at that time cared about the inner thoughts of users, but in the 1990s, Dervin (1992) turned into the contextual environment and proposed the idea that the essence of the communicating moment by users 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.

Dervin (1992) notified readers to be aware of user perspective rather than the perspective from the systems, which can be significantly inferred that the study of information use should also employ a user-oriented and cognitive approach to focus on the process of constructing knowledge, and to further investigate every step that users take when they are trying to build up the bridge and across the gap. Vakkari (1997, pp. 461-462) agreed that information has been used to make sense in the gap situation. Furthermore, Dervin took "sense-making" as a constructing process. However, Savolainen (2006, p. 1120) asserted that when people are constructing bridges, sometimes also deconstructing them. Overall, Dervin continues to alter her concern towards "sense-making" and fine tune the methodological

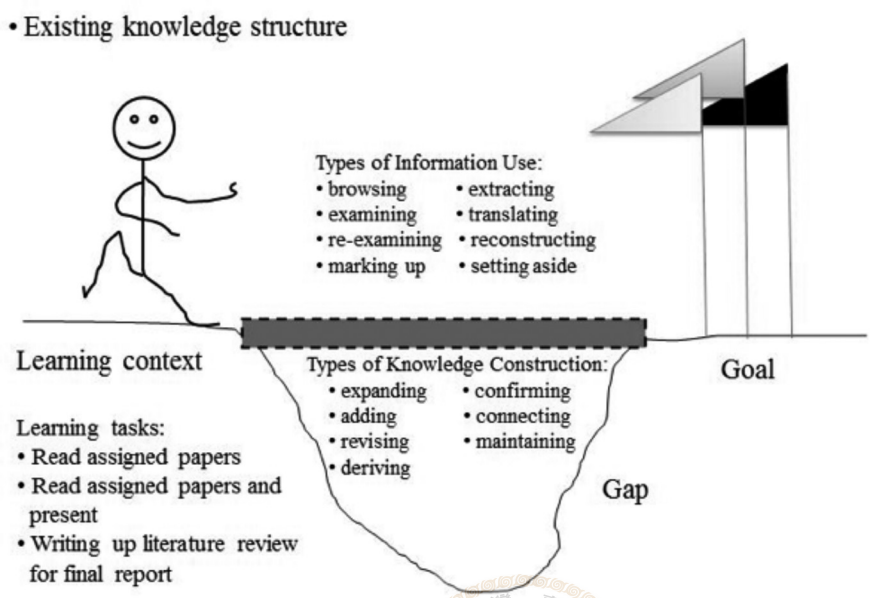


Figure 2. Research Framework

Note. Adapted from "*Sense-making Methodology Reader: Selected Writings of Brenda Dervin*," (p. 277), by B. Dervin & F. W. Lois, 2003, Cresskill, N.J: Hampton Press. Copyright 2003 by Hampton Press.

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interpretation and interviewing skills to develop a well-defined methodology.

One of the graduate courses in Library and Information Science (LIS) Master Program was selected as research context for its diversity of learning tasks taking place throughout the semester. In the class, students were asked by the lecturer to read assigned papers. Each of the students in the class was also assigned to read a certain paper and present the main idea of the paper in class. Lastly, students were required to write up literature review on a topic that needs to be approved by the lecturer for final report of the course. The exercises assigned in the course were presented as the learning tasks that need to be accomplished to reveal how the students employ information to bridge knowledge gap in the process. Figure 2 shows the research idea that was originated from the graphical illustrations of sense-making framework with the intention of concretizing the heuristic metaphors of step-taking and gap-bridging.

According to Figure 2, the informants in the current study were immersed in a learning context and faced gap before using information to construct knowledge. In the progress of learning new knowledge to bridge the gap, students might undergo the process of knowledge construction and achieve the ultimate goal at the end of the course. Qualitative techniques were applied in data collection, including participant observation, document analysis, diaries, interview, and pre-/post-course tests.

The current qualitative-centered study mainly employed content analysis to extract meaningful data in order to achieve immersion and obtain a sense of the the preliminary findings by revisiting any clues and nodes, then labelling the notes for thoughts and nodes to form the initial coding scheme. Codes were later sorted into meaningful clusters or categories to develop a hierarchical structure and concept. Exemplars for each code and category were identified, and the relationship between categories and subcategories were further developed for reporting the findings (Hsieh & Shannon, 2005).

Pilot study was conducted in another course from the same master program before the current study. One of the authors joined the class as a participant-as-observer for one semester. From this experience, the authors found that the best way to collect data in a learning setting would be as an observer-as-participant to fully focus on the respondents. Otherwise, the observer would be easily distracted in the lectures.

Table 1. Background Information of Informants

Academic background	Part-time	Full-time
Bachelor's degree in LIS	1 informant in Year 3 1 informant in Year 2	2 informants in Year 2
Bachelor's degree **in other fields**	1 informant in Year 2 1 informant in Year 1	3 informants in Year 1

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3.2 Sample

The authors saw prior knowledge as a factor which might influence the learning outcome based on the findings of McNamara and Kintsch's (1996) research. McNamara and Kintsch (p. 252) stated that the comprehension of incomplete tests relies on the "comprehender to fill in gaps and make links to prior knowledge to form a situation model of the text." The prior domain-specific knowledge and the building of a coherent situation model are therefore the driving factors. Hence, the current research included study objects with different knowledge background in this study. The informants chosen for this study are with different educational or working experiences, including the students who obtained bachelor's degrees in LIS and the ones in other fields who study either full-time or part-time. The students are in different studying stages of master program. Nine informants from the same program were invited to participate in this study after obtaining the consent from lecturer for taking the course as the research context. The lecturer of the studied class also reviewed the questions of pre-/post-tests to ensure the validity of the tests. Table 1 provides more details about the informants.

Since the aims of this study are to reveal how information is used during the process, and how the knowledge structure is changed under the influence of information use, several instruments were designed to collect data and the action of data collection was carried various times during the study period.

To gather data about how information is used by the participants from the clues left on the information, the authors collected learning materials used or produced by the participants, such as self-driven diary, copies of read printed papers, slides, etc.

3.3 Data collection

3.3.1 Pre-/post-tests

To better understand the knowledge status in different stages, each informant was asked to fill out the pre-/post-course tests, which were drafted by the authors and reviewed by the lecturer. We collected data for prior knowledge of the participants in the pre-test and the data to show the knowledge status after information use and course taking in the post-test. There are ten questions for the pre-/post-course tests which are related to the main topics of the course (See Appendix A). Furthermore, the participants were asked to answer three to four questions about the assigned articles before reading them. After the presentations, they were asked to complete the test again. The data from the tests provides the authors the evidence to reveal what the informants know about the topics and possible changes of knowledge structure after utilizing information acquired during the learning process.

3.3.2 Learning diary

To reveal learning experience, the informants were asked to write a learning diary to record the activities during the course, such as information seeking activities and information use behavior. The diary gives the authors a different view of learning process and a chance to observe the activities behind the scene. The diary solely serves as important cues for later interviews and observation. For detailed information of the format of diary, please see Appendix B.

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3.3.3 Document analysis

To gain more ideas about knowledge structure before and after utilizing information, copies of read printed papers and notes taken in class were seen as tokens for knowledge representation and were collected as well. Document analysis has been conducted to explore how the knowledge is constructed by investigating the structure of answers to same questions at different learning stages. By examining the copies of assignments and notes, the authors could see how did the informants process the information obtained and understand the knowledge structure of informants while applying the information.

3.3.4 Semi-structured interview

Face-to-face interviews were conducted twice for each informant during the semester. The first one was conducted based on the learning diaries provided by participants (See Appendix C) and the second one took place right after the presentation for the assigned articles (See Appendix D). In the latter interviews, the informants described how did they use the information obtained, and furthermore they responded to the interviewers' questions regarding the assigned articles. The purpose of the interviews is to better understand the actual information use behavior and to probe into the existing knowledge structure of each informant by asking course-related questions.

3.3.5 Observation

One of the authors entered the learning scene as teaching assistant for data collection for one semester by taking observer-as-participant approach. Not only the interaction among informants and the lecturer were observed, the actions taken by and presentations given by informants had also been observed and recorded to further explore how the students represent the information and knowledge obtained verbally.

3.4 Data analysis

To gain insights into the process of knowledge construction and information use, the authors examined the distribution and completeness of statement nodes, aspects covered in description and arguments. Thus, the authors extracted emerging issues, themes, and patterns by revisiting observation notes, diaries, transcripts, read papers, presentation slides, and other knowledge representation provided by participants. By using grounded theory of Glaser and Strauss (1967), the authors analyzed the data from initially identifying key points to forming several categories via grouping similar concepts, which generated information use behavior in the context of knowledge construction.

To ensure the credibility of the results, the informants had been asked to review the interview transcripts to confirm the accurateness of the data collected. Then, the authors generated the main themes based on nine informants' interview transcripts and triangulation with other data was carried out, such as answers to open-ended pre-/post-course tests, diaries about information use, printed copies of read papers, notes taken in class to verify the actual status of knowledge structure and information use behavior, so the credibility and validity of the results could be ensured.

In order to reveal proper categories and concepts that are unique to this study, the authors used the findings of previous studies, such as Driver's (1988) five stages of knowledge construction and Cole's (1997) five phases of information use, as the basis of open coding and

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adjusted the labels based on the studied context. Tables 2 and 3 show the research results of previous studies on knowledge construction and information use, and the results were applied for later data analysis.

4. Results

The major findings show that the participants used course related information in different manners while constructing knowledge, including browsing, examining, re-examining, marking up, extracting, translating, reconstructing or setting aside, to understand the concepts taught in the class. The activities and strategies could be seen in a repetitive and dynamic loop until the task was accomplished.

4.1 Knowledge construction

In the learning context, the authors found that there are four main phrases during the gap-bridging process. The participants would begin with evaluating the attributes of learning tasks

Table 2. Previous Studies on Knowledge Construction

Author(s)	Knowledge construction				
Rumelhart & Norman, 1981	accretion		tuning	restructuring	
Piaget, 1985	assimilation		accommodation		
Driver, 1988	orientation	elicitation	restructuring	application	review
Chi, 1992	addition	discrimination	deletion	generalization	
Todd, 1999	appending	inserting	deleting		
Todd, 2006	additive		integrative		
Chi, 2008	adding		gap-filling	changing	

Table 3. Previous Studies on Information Use

Author(s)	Information use							
Caplan, 1980	conceptual utilization				instrumental utilization			
Taylor, 1991	enlightenment	problem understanding	instrumental	factual	conformational	projective	motivational	personal or political
Cole, 1997	opening of the information process	representational (cognitive) activity		corroborating	closing of the information process		effect of information process	
Saracevic & Kantor, 1997	acquisition				cognition		application	
Wang & White, 1999	selecting				reading		citing	
Wilson, 2000	physical				mental			
Spink & Cole, 2006	potential use				real use			

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designated by the lecturer of the studied class, the complexity of information involved and the difficulty of learning tasks, while the participants would review the existing knowledge structure to identify possible knowledge gap. Participants would decide whether other information was needed and how they could use the information to bridge the gap to achieve the goal of this class.

It is noteworthy that the stage of reviewing knowledge gap is essential to the process of knowledge construction. Participants took action based on the existing knowledge structure and might move backward to previous stages to restart further actions. In general, the process of knowledge construction is not only a linear course of actions but a dynamic and iterative loop. The process won't be completed until the participants feel gaps have been filled and construct relevant knowledge structure. Figure 3 is a visual presentation of the process.

4.2 Knowledge structures expanded

It is found that the nodes in participants' knowledge structure were expanded both horizontally and vertically by extracting, translating, examining, and re-examining information. Nodes were placed on the existing structure with hierarchical linkages, making the knowledge structure much more complete. Hence, participants may explain certain concept further in different ways or aspects. For example, one of the participants used to take the quality of metadata as an abstract notion. However, after reading one article regarding this topic and using relevant information, the participant could provide definition and ways of defining the quality of metadata.

Apart from expanding knowledge structure, new nodes could have been added on new branches in the structure by examining information. In the same way, participants may also revise the contents and position of nodes, or even derive relevant nodes from different knowledge structure based on his or her working and learning experiences. Re-examining information could lead to the nodes being revised, connected, and confirmed. With the assistance of the exemplars provided by the lecturer, participants could connect the nodes together that were once independent and irrelevant. By communicating with peers in study group every week before the class, informants may confirm their cognition toward certain topics. Meanwhile, knowledge structure might remain the same after browsing, marking-up, re-constructing, and extracting information.

Vertical and horizontal nodes on the knowledge structure were generally developed in this study. Vertical nodes refer to the broader or narrower concepts related to a specific topic, and the horizontal nodes present the siblings concepts

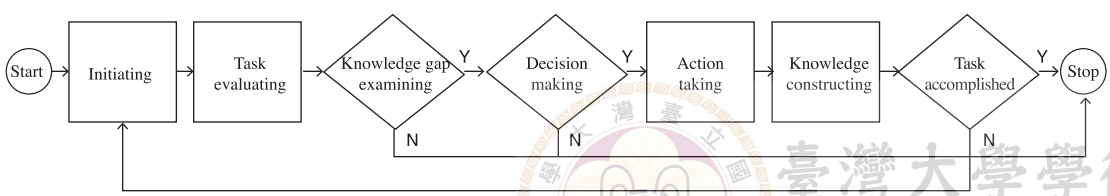


Figure 3. Knowledge Construction

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associate to the linked topic. In addition, some of our participants tended to focus on terminologies first while dealing with new information. For example, one specific participant defined FRBR simply as a conceptual framework before the course. However, the participant developed vertical nodes, such as the concept of entity-relationship model under conceptual framework, and further asserted the horizontal nodes, such as searching, identifying, selecting, and obtaining, under the concept of user tasks during the mid-term of the course by focusing on the terminology and examining relevant information.

Hierarchical structure and the distance of nodes were also changed after using information. Figure 4 shows the distribution of nodes generally discovered in the study. Clear evidence shows that one specific participant defined metadata (node D in Figure 4) as a simplified schema (node A) to describe items, and even made a comparison between MARC (node B) before the course. It is observed that the participant treated metadata and MARC as different nodes but on the same hierarchy. As the knowledge structure constructed, the previous statement has been changed during the mid-term by indicating that metadata itself is to describe items and further stated that MARC is also one type of metadata, so are MODS and DC schemas. From the later statement, it was observed that for the participant, metadata is no longer on the same hierarchy with MARC but a superordinate and broader term for schemas like MARC, MODS, and DC. The distance between metadata and MARC used to be short but have become extensive due to the change of knowledge structure. Furthermore, new branch of nodes has been developed based on participants' working or learning experiences. For example, one of the participants partially disagreed with the idea of bibliographic control in the future and believed that possible difficulties could happen in the workflow. The participant indicated that the concept is unpractical by taking a small-scale library (node H) as an example based on her previous working experiences at cataloguing unit in an academic library.

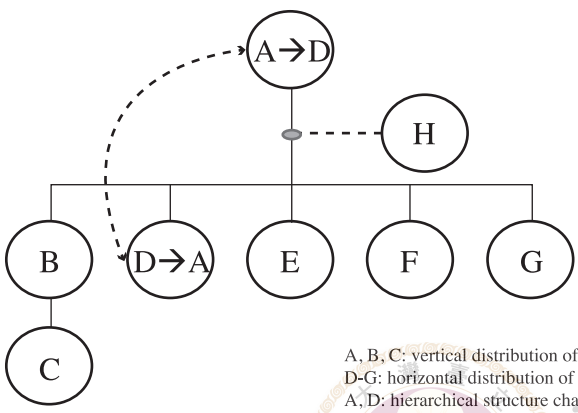


Figure 4. Distribution of Nodes

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4.3 Examining, re-examining and translating information are most prevalent during knowledge construction

The results show that examining, re-examining and translating information are the most frequently observed information use behavior during knowledge construction.

Examining refers to carefully reading assigned papers and relevant information in order to understand certain topics. Furthermore, participants examined information repeatedly when they were still puzzled. Besides, group discussion and asking other classmates for help were also other presentations of re-examining information. During discussion and inquiry, participants would focus on certain parts of information and seek the most reasonable explanation when they were dealing with some confusing information delivered in the class. Re-examination of information would make participants understand information well when every piece of information was apprehended.

Translating refers to literally translating information from one language to another or semantically translating information via various representations after comprehending the meaning of information. Since the materials assigned by the lecturer were mostly in English, the participants tended to translate the contents into Chinese first to better understand the meaning of information. Semantically, participants would also translate the information in the same or different languages received from various sources, e.g. written and verbal messages, to his or her understanding. Hence, certain knowledge can be constructed when the semantic translation succeeds.

4.4 Linkages among information use, knowledge construction, and knowledge representation

At the beginning of the course, participants were not familiar with several main topics. Hence, some questions in open-ended pre-course test were left unanswered or simply indicated, "(I) do not know." After the assignments were given, participants would start to evaluate learning tasks by browsing information and examining their own knowledge structure to identify knowledge gap. Examining knowledge structure is essential and occurs at all stages during the course of knowledge construction. The process stops once the participants find their current status of knowledge structure sufficed enough to deal with the information received in the class.

Participants decided how the information should be used to construct knowledge. During the course of action, participants started from browsing information, and may set aside information if it is too complicated and overwhelming. Participants may also mark-up, extract, and reconstruct information to gain better understanding. Above all, knowledge structures did not change, so that participants may not elaborate on certain topic or the statement simply remained the same. With the expanded nodes, participants were able to state several concepts in different ways or aspects. They would also assert further if the nodes were added onto knowledge structure, or express their own opinions on various issues based on working and learning experiences. Figure 5 demonstrates the linkages among information use, knowledge construction, and knowledge representation.

During the stage of Take Action, there are interconnected relationships in the context of

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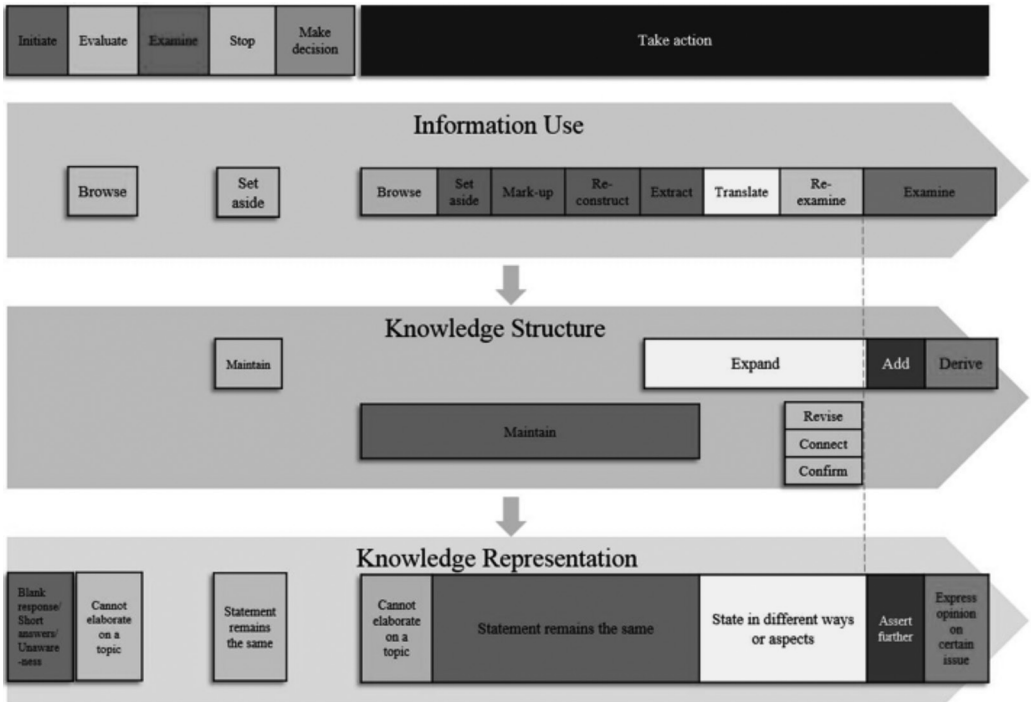


Figure 5. Linkages Among Information Use, Knowledge Construction, and Knowledge Representation (Note 1)

Information Use, Knowledge Structure, and Knowledge Representation. The dash line in the figure indicates that examining in information use could also lead to knowledge structure expanded and statement in different ways of aspects.

The authors found that the prerequisite courses equipped the participants with bachelor's degrees in other field sufficient prior knowledge to continue the advanced course. The learning outcomes show that the 1-year prerequisite courses in master's programs cover the topics on basics of library and information science, information acquisition and organization, and reference materials and services, which are essential in constructing prior knowledge in the field of Library and Information Science. By examining the answers to the pre-/post tests and the answers to the questions raised in the interviews pertaining to the assigned papers, most participants with bachelor's degrees in other field provided fairly completed the answers, while no significant difference were found on the answers provided by the participants with bachelor degree in LIS. Therefore, the possession of prior knowledge from 4-year courses in bachelor's degrees in LIS and the 1-year prerequisite courses in master's programs plays a vital role. In this case, informants would mainly construct knowledge by having existing knowledge structure expanded. The findings are consistent with the statement of

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several researchers (McNamara & Kintsch, 1996, p. 248; Recht & Leslie, 1988) who proposed that prior knowledge "facilitates and enhances comprehension and learning." In addition, it is also found that the working experiences in the LIS field are helpful for the full time graduate students with a bachelor's degree in LIS to develop additional branches of nodes in the knowledge structure.

5. Discussion

The findings of this research are consistent with previous studies. For example, facts influence decision making before using information are explored. The authors also observed that the knowledge structures were mainly expanded in the present study. Below are the discussions of previous studies and our research in terms of knowledge construction, the relationship between knowledge construction and knowledge representation, and information use behavior in the process of knowledge construction.

5.1 Constructing knowledge

The results show that participants would review current knowledge structure repetitively, and then take action based on the existing gap, the importance of learning tasks, and the complexities of information. The result is consistent with the statement of Savolainen (2006) which denotes that subject would evaluate and define the gap ahead and bridge the gap with strategies and tactics. In our study, the process of knowledge construction would stop once the gap is being bridged or the information is considered too complicated to be used.

Driver's (1988) and the current study share the same studied context and similar results. Both studies were conducted in a learning environment and find that subjects start *evaluating* received information, so as to decide the ways of using information. Meanwhile, *reviewing* in Driver's (1988) study refers to the examination of knowledge structure by comparing the final ideas with the ones in elicitation stage to reveal conceptual changes. However, *reviewing* in present study might occur in every stage.

Previous studies aim to formulate the whole process by merely investigating the changes in knowledge structure, but seldom taking the context into account. Several studies conclude that knowledge structure would be altered in two major parts, addition and reconstruction (Chi, 1992, 2008; Rumelhart & Norman, 1981; Todd, 1999, 2006). However, the present study discovers that the nodes of knowledge structure would be added on and mainly expanded based on the existing knowledge structure, which is consistent with the statement of Chiesi, Spilich and Voss (1979, pp. 270-271) that the encoding of input information is mapped onto a sufficiently developed existing knowledge structure.

5.2 The relationship between knowledge construction and knowledge representation

It is worth noting that the knowledge structures have been majorly expanded or added after reviewing the knowledge representation on the transcripts and the open-ended pre-/post-tests for the assigned papers.

Previous studies focus on classifying the attributes of knowledge representation, while the present study relates knowledge representation to the status of knowledge structure, including blank answers, inability to elaborate on a topic,

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unchanged statement, stating in different ways of aspects, further assertion, and other forms of knowledge representation. Chen's (1999) and the present study both focus on the investigation of the changes in knowledge representation during the course of knowledge construction. Moreover, the studied context of Chen's was set in designing hypermedia documents and the present study investigates the relationship between knowledge structure and knowledge representation in a learning environment.

5.3 Information use behavior in the process of knowledge construction

Cole's (1997) and our study both share similar results that subjects would verify the authenticity of information by using other information and examining self-knowledge structure. The process of information use proposed by Cole is a linear course of action, yet our study discovers iterative and dynamic action in the process of using information, as participants of this study would interchangeably use existing or other possible information to bridge the gap by examining present knowledge structure.

Furthermore, the representations of information created by others in the present study facilitate interpretation of the information assigned for the course. Those heavily used information, such as the PowerPoint slides, were created by deconstructing the assigned papers and further re-constructing after understanding the context of the assigned information. Those representations are far more comprehensible to students rather than the original assigned information.

6. Conclusions

6.1 Factors influence various types of information use behavior

6.1.1 Prior knowledge

Owning to the possession of prior knowledge and the advanced feature of the studied class, the participants assimilated the information received in the learning context and had knowledge nodes expand on existing knowledge structure.

6.1.2 Task types

To perform learning tasks, the participants would evaluate the importance of learning tasks and take time limit and different forms of knowledge representation into consideration. For instance, most of the participants put more effort into reading the assigned papers thoroughly that are responsible for presenting in the class, but paid less attention to other assigned papers. Therefore, the participants would rather spend more time on preparing the assigned papers to share with the class, leaving limited time to browse other assigned papers. Participants would use the information in native language and the PowerPoint slides created by other classmates simply because those materials are easier to understand.

6.2 Changes of knowledge structure

The various outcomes of knowledge representation indicate that participants may not explain more on specific topic by only browsing information, but express further in different ways or aspects by examining, re-examining, extracting, and translating information. The attributes of learning tasks influence the ways of using information and the outcomes of learning. However, participation in the study group might facilitate information use from not only browsing

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but examining other assigned papers, so that learners might achieve learning goals to a greater extent.

6.3 Suggestions

The results of the study indicate that the ultimate outcomes of information use and knowledge construction varied due to the existing prior knowledge and the effect of learning tasks given in the course. In view of the aforementioned perspectives, incoming students who take advanced courses with practical hands-on knowledge may benefit intellectual and mutual communication with other students to gain insight into the information perceived in the courses.

The study also discovers that participants not only rely on the abstract of articles to gain initial understanding, but headings in articles could help readers grasp the overall meaning of articles efficiently. Hence, to better provide information services, information providers such as publishers, vendors, and libraries, could highlight the service of extracting outline of articles to present page preview for readers. Furthermore, information providers could even develop certain software to extract frequently-showed words other than the keywords given by authors based on users' relevance judgment and preferences.

Prior knowledge of students is essential during the process of knowledge construction and information use. Thus, understanding the status of students' prior knowledge and designing appropriate prerequisite courses to develop prior knowledge are necessary, so as to ensure that students understand the information taught in the advanced courses.

For future studies, the setting could be expanded to other fields or educational systems, in order to comprehend the overall situation of information use and knowledge construction. Apart from the learning settings, investigating information use behavior in daily life is indispensable, yet with greater difficulties to conduct. Practitioners in libraries may refer to the results of this study in designing an information system and providing reference services to better meet the needs of users.

6.4 Acknowledging exceptions and limitations

A limitation of the study is the relatively focused and natural learning context in the course for a master's degree, which limits generalization to other settings. For this reason, the findings might not be applied to the broader community. The knowledge representation and learning outcomes of the participants are not limited to those major aspects discussed in the study. Participants may construct other knowledge that is neither relevant nor covered in the top ten main topics of the course.

Notes

Note 1 The rectangle on top of Figure 5 composed of different colored boxes without shading refers to the whole process of knowledge construction in the studied context, below the bar are the Information Use in blue shading, the Knowledge Structure in brown shading, and the Knowledge Representation in green shading, each with different colored boxes that can be related to each individual process of knowledge

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construction. For example, the orange box labeled 'Stop' on the upper left corner can be corresponded to the same-colored boxes labeled 'Set aside', 'Maintain', and 'Statement remains the same' in Knowledge Representation, which means that some participants do not use more information since the original knowledge structure is sufficient for them to deal with the information. Thus their understanding towards certain issues and the relevant knowledge representation remain the same.

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Appendix A

Open-ended pre-/post-course tests

Note: To reveal the extent of understanding the main ideas of the course, the open-ended tests will be delivered before and after the studied course.

1. What are the components of Technical Services? What do you see the relationship between Technical Services and Public Services?
2. Please explain what FRBR means to you and how to implement FRBR in library catalog?
3. Can you explain what metadata is? Different types of metadata are designed for different purposes, and might be employed in different digital archive projects. If those projects apply different metadata, is it necessary to consider the interoperability of metadata? Why?
4. What are the criteria for the Next Generation OPAC?
5. What is the role of subject analysis in the digital era? Please explain how to do subject analysis for digital resources?
6. What are the differences between social tagging and subject headings? Do you see any relationship between these two concepts?
7. What is the function of authority control? What would be the bibliographic control in the future?
8. Regarding organizing electronic resources, what are the difficulties library will face? Are there any possible solutions for the issues?
9. What are the duties and jobs that cataloguers are responsible for nowadays?
10. Is there any relationship among institutional repository, digital archive, and OPAC? Please explain.

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Appendix B

Learning diary

Note: The purpose of having participants write learning diary is to better understand the overall information use behavior and to serve as the foundation for further interviews.

Please write down the following information after using information each time.

1. The date and time of using information
2. The material types and content of the information used (e.g. books, journals articles, websites, slides)
3. What was your perception towards the information that is going to be used?
4. How did you use the information? (Please specify)
5. How long did it take to use the information?
6. How many times did you use the information? (e.g. read certain article twice)
7. What did you learn from using the information each time?

You could either write the diary in MS Office files or notebooks, which were provided by the researchers.

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Appendix C

Outline of interview- based on the learning diary

Note: The outline is designed for the semi-structured interview which is based on the learning diaries provided by the interviewees, and the contents are subject to change or expand according to the feedback from the participants.

1. What was your understanding before using the information?
2. How did you use the information?
3. Why did you use the information?
4. What kind of criteria did you use to identify what is crucial in the information?
5. Did you find information other than assigned materials helpful?
6. How did you use other information?
7. What did you apprehend after using information?

Appendix D

Outline of interview based on the answers to the open-ended pre-/ post-tests before for the assigned presentation

Note: The open-ended test is delivered before reading the assigned article and after the presentation to reveal the extent of understanding the main ideas of the articles.

1. What did you know about the main themes of the assigned article before you read it?
2. How did you plan to understand the ideas that the author(s) trying to explain in the article?
3. Did you use other information when you were reading the article? (If the answer is positive, the following three questions will be developed)
   3.1 What other information did you use?
   3.2 Why did you use other information?
   3.3 How did you use the other information?
4. How did you identify the main idea of the assigned article?
5. How long did it take to read the assigned article? How many times did you read the article?
6. Was there any part of the article that had been read repeatedly?
7. How did you prepare for the slides for presentation?
8. How did you prepare for the oral report?
9. Overall, what did you learn and feel about the presentation?

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從知識建構探索研究生之資訊使用行為

Exploring Information Use Behavior in the Context of Knowledge Construction

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摘　要

本研究以Brenda Dervin的意義建構（sense-making）為理論基礎，在任務導向之學習新知情境下，探究研究生在建構知識的過程中，如何使用資訊以彌補知識落差，進而建構課程相關知識。研究採質性研究方式設計，研究者以觀察者身分進入研究場域，觀察授課教師與研究對象間之互動及研究對象於課堂中之參與程度，以深度瞭解研究對象的「資訊使用」行為與對課程中主要概念之認知狀態。

透過參與觀察、深度訪談、學習日誌與前後測問卷等方法蒐集資料，研究對象使用之文獻資料、學習筆記亦納入分析資料範圍。研究運用「概念式圖像結構（Conceptual Graph Structures）」分析知識表徵中之各項陳述節點，藉由掌握節點間之關係，分析研究對象對於特定概念之知識結構，並以紮根理論為基礎，由最廣泛的資料限縮至具象徵性之主題，並從主題中辨識出所代表的概念。

研究發現知識建構起始於接收到課程中所賦予之學習任務，並評估學習任務屬性及資訊內容複雜度，同時檢視自我知識結構以決定後續資訊使用方式，進而有所行動。在建構知識過程中，研究對象透過資訊的瀏覽、檢視、反覆檢視、標註、擷取、轉譯、重組等方式處理所獲得的資訊，或將資訊擱置不做處理。研究對象之「資訊使用」行為會因任務屬性不同而有所差異，且研究對象多具有課程相關主題之先備知識，因此知識結構的改變多以擴充知識節點為主。由研究中可以得知任務之重要性、資訊之語言、類型或呈現形式不同，以及時間等因素會影響研究對象使用資訊之方式。

關鍵字：資訊使用、資訊行為、知識建構、知識表徵

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