Development of an Information Base Tool for IDT Research

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Dissertation submitted to the faculty of Virginia Polytechnic Institute and State University

In partial fulfillment of the requirements for the degree of Doctor of Philosophy

In

Curriculum and Instruction

(Instructional Design and Technology)

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September 3, 2014

Blacksburg, Virginia

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ABSTRACT

Identifying and articulating a research topic and related problems are important processes for novice researchers. However, some novice researchers have trouble in these processes due to their low domain knowledge, low structural knowledge, insufficient metacognition, or insufficient information access skills. This study addressed these problems by developing an information base tool using strategies and tools investigated by previous studies. The tool includes conceptual modeling, guided search, experimental variables and relationships examination, note-taking, suggestion, file import, and review features. The tool was populated with relevant information to permit testing and formative evaluation by novice researchers. Expert reviewers evaluated the effects of each feature of the tool on scaffolding individuals who have low domain knowledge or low structural knowledge and supplementing individuals who have insufficient metacognition or insufficient information access skills. The reviewers commonly agreed that specific components of the tool would be effective in scaffolding individuals who have low domain knowledge or low structural knowledge, or supplementing individuals who have insufficient information access skills.

Acknowledgements

First and above all, I would like to thank my adviser, Dr. Kenneth Potter. I could not have finished my study without him. He has provided me with insightful guidance and warm encouragement. I have really enjoyed the discussions with him. I am also very thankful to Dr. Barbara Lockee. She has been supportive and given me many chances to experience various projects that could advance my knowledge. I must also acknowledge Dr. John Burton for his special encouragement and advice. He is a great researcher and has showed me how I should behave as a researcher. I am also very grateful to Dr. Jennifer Brill for her meaningful advice for my study. She has given me much help that improved my research.

I owe a debt of gratitude to my friends who studied or are studying in the Instructional Design and Technology program at Virginia Tech. They have provided meaningful feedback on my study. I also extend my sincere gratitude to the three professional researchers who participated in this study as expert reviewers. They have provided insightful opinions on this research.

I would like to thank Dr. Sangkyun Kim. He has provided me with help and advice for my research and career planning. He is a great mentor to me. I also would like to acknowledge Dr. Byeonghee Park. He has always encouraged me during my research.

Special thanks should also be given to Mr. and Mrs. Grace, Terry Davis, Lori Berry, Dr. Diana Wu, Dr. Hyomin Kim, Yunchu Cheong, Hyungil Kim, and Hyunsook Cho. I was able to finish my study with their kind help. Whenever I need help, they have been by me.

I am deeply thankful to my family for all their love, support, patience, and sacrifices. Joungah Han, Seonbin Song, Kyoungseop Song, Myoungsoon Cha, Jongok Han, Kyoungja Na, Kiseon Song, Youngah Han, Myounggoo Choi, Seungho Han, Seungah Hong, Soojung Han, and Dongyoon Ok. All these family members have been supportive and encouraged me during my study. I gratefully acknowledge my wife, Joungah, in particular. Without her sacrifice, this dissertation could not have been completed.

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Chapter 1: Introduction and Need for the Study

For novice researchers, identifying and articulating a research topic and related problems are crucial to becoming an independent researcher. However, many novice researchers have trouble finding one clear research problem because they do not have sufficient domain knowledge in their fields. In addition to the low domain knowledge, their knowledge is not highly organized. As a result, it is difficult for them to locate, evaluate, and synthesize relevant information.

As a first step for research, finding an appropriate research problem demands an understanding of what problems have already been solved and what problems have not been investigated. This understanding may be developed through literature reviews including interpreting and synthesizing previous studies. Benge, Onwuegbuzie, Mallette, and Burgess (2010) revealed the ability to interpret empirical articles is influenced by prior domain knowledge, research skill and knowledge, and vocabulary in a domain. Moreover, low prior knowledge causes difficulties in generating hypotheses, interpreting data (Land, 2000), and conducting systematic inquiries (Glaser, Schauble, Raghavan, & Zeitz, 1992).

Need for the Study

Multiple strategies and tools have been suggested to support the ability to identify research problems. Carey (1986) suggests the use of concept maps as a research tool to support researchers to understand the flow of knowledge in a domain. Mayer (1999) and Shapiro (2008) claim that the use of external modeling facilitates conceptual changes. Winn (2008) argues that constructing and testing of hypotheses also facilitate conceptual changes. Similarly, Jonassen and Ionas (2008) claim that simulations or causal modeling tools can aid modeling of causal relationships. However, existing electronic databases frequently used by researchers to locate relevant literature may have limitations in providing researchers with meaningful help due to the nature of their organization and their absence of information to help novice researchers understand research problems, purposes, methods, and results of each research. Therefore, there is a need to develop a tool that supports novice researchers in their efforts to effectively and efficiently understand what problems have been examined in the field.

Purpose Statement of the Study

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The purpose of the study is to develop an information base tool that provides support functions for novice researchers to help them identify current research problems by addressing prior research problems, purposes, methods, and results of research studied in IDT field. For purposes of this study, novice researchers are defined as individuals who conduct research in a field, but do not have enough domain and structural knowledge in the field to identify researchable topics. The study describes in detail the development procedures, the features of the information base tool, the conditions for facilitating the tool's use, and strategies for populating the information base tool. It can be anticipated that not only novice researchers but also experienced researchers in IDT and other related fields will use the information base tool to examine the flow of research in the IDT field and identify research problems.

Research Questions

In this study, the following questions were studied:

1. Based on a review of relevant literature, what features should be included in the information base tool?

2. How might be the features operationalized to support novice researchers?

Benefits of the Study

The study can facilitate novice researchers' growth as independent researchers. It can also promote not only research in the field, but also interdisciplinary research among various fields by supporting researchers in other fields. Additionally, this study provides a framework that can be used to design and develop an information base tool with studies and practices in other fields of study.

Organization of the Proposed Study

Chapter One introduces background information and explains the need for the study, the purpose of the study, research questions, and benefits of the study. Chapter Two deals with a literature review of three issues associated with the construction of a theoretical framework. The first section in the chapter describes the concept of knowledge organization from the viewpoint of cognitive psychology and explores relevant literature that describes how knowledge structures are arranged and accessed. The second section reviews the factors influencing novice researchers' ability to identify a research problem and the solutions to support the novice researchers. The last section of this chapter focuses on the previous efforts to develop

information bases that have IDT related knowledge or information. Chapter Three explains the methodology employed in the study. This chapter contains the study design, settings, participants, and procedures. Chapter Four describes the final tool and the findings of the study. Chapter Five discusses lessons learned from the study and directions for future research and practical use of the tool.

Chapter 2: Review of the Literature

The purpose of this study is to develop an information base tool that helps novice researchers identify and articulate a research problem. The literature review of this study focused on following three questions:

- How is knowledge arranged and accessed?
- What factors influence novice researchers' ability to identify and articulate a research problem and what strategies and tools can support the ability?
- What are the characteristics of knowledge bases and information bases in IDT and how are they designed?

Knowledge Organization

Knowledge is information about the world that is stored in memory (Smith & Kosslyn, 2006). From the viewpoint of cognitive psychology, knowledge is the content of long-term memory. While behaviorists place less emphasis on the internal process of the human brain in learning and performance, cognitivists have been more interested in people's mind and human memory. One of their research interests is on how to organize knowledge. This section includes the notion, importance, forms, and mechanisms of knowledge organization.

The organization of knowledge has been defined as the integration of new information into a body of existing knowledge (Ausubel, 1962, 1963; Klatzky, 1980; Mayer, 2001). The organization of knowledge has been viewed from several perspectives, including the structural and process perspectives. Some researchers (Reif, 2008; Sternberg & Tulving, 1977; Tulving, 1962; Tulving, 1968) argued the organization of knowledge can be defined as relationships among its component elements from a structural perspective. Other researchers examined the organization of knowledge from a process perspective involving encoding, or retrieval, or both encoding and retrieval. For example, Ausubel focused on the role of encoding while Bousfield (1953) focused on retrieval when stating that the organization of knowledge means clustering of categorically related knowledge elements in free recall. Klatzky (1980) insisted that the organization of knowledge can be regarded as a process that includes both encoding and retrieval and that retrieval from long-term memory is improved when information is stored as an organized unit.

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The nature of the organization of knowledge in a domain determines the quality of internal representation (Gagné, 1987; Glaser, 1986). Knowledge organization during encoding also affects retrieval due to encoding specificity, which means that the cues used to facilitate encoding can be used as the best retrieval cues (Thomson & Tulving, 1970; Tulving & Thomson, 1973).

There are some empirical studies that show the importance of well-organized domain knowledge in various areas (Adelson, 1981; Bower, Clark, Lesgold, & Winzenz, 1969; Chase & Simon, 1973; Chi, Feltovich, & Glaser, 1981; Chi & Glaser, 1985; Hmelo-Silver & Pfeffer, 2004; Khalifa & Shen, 2010; Kintsch & Keenan, 1974; Larkin, 1980; Rasmussen & Jensen, 1974; Reif, 2008). From such studies, the benefit of organized knowledge has been proved and the differences between experts and novices in terms of their knowledge organization have been investigated. Experts usually have more organized knowledge than novices and tend to hierarchically organize new information. According to Ausubel, Novak, and Hanesian (1978), if knowledge structure is suitably organized, accurate meanings can be expected, but if knowledge structure is disorganized or chaotically organized, meaningful learning and retention can be inhibited.

Research on knowledge structure has been conducted from various perspectives in an attempt to understand how knowledge structure is arranged, accessed, and used. The following sections will discuss some of these perspectives including the network model, feature comparison model, propositional model, parallel distributed processing (PDP) model, and schema model.

Network Model.   The network model is a web of interconnected elements of meaning (Collins & Quillian, 1969). In the network model, each element is represented in a node, and the labeled links among the nodes denote relationships among elements. The links are pointers, which are reflected in the strength of links connecting elements in a network structure that represents knowledge. Considering the network structure, it can be hypothesized that some concepts are remarkably close together while the other concepts are relatively far away from each other. Collins and Quillian (1969) support the hypothesis through their investigation. They claim that predictions can be enabled by the network models and that the response speed to a certain sentence is faster than to other sentences. In some sentences, search in a network has to

proceed to one or two pointers; in other sentences, it has to proceed to more pointers. In the network models, there are five kinds of links: superordinate and subordinate links, modifier links, disjunctive links, conjunctive link, and residual links (Quillian, 1968). These links can explain how individuals recall specific information in an efficient way.

The hierarchical network model (Collins & Quillian, 1969), as one of the network models, has hierarchically organized concepts and uses intersection search, which means that stimuli enter the network at two concepts and search for a connection. Like other semantic network models, the hierarchical model shows an interconnected relationship among elements, but in a more systematic, treelike fashion. In hierarchical networks, a person does not need to search all information in the network to access certain information because this structure contains categories that minimize redundancy and provides hierarchical levels for each concept. A concept at the higher level of a hierarchy can be applied to other concepts at the lower levels in the hierarchy. In other words, concepts at the lower levels inherit the properties of a concept at the higher level. The inheritance makes hierarchical networks efficient in accessing certain information. A few researchers have revealed empirical evidence that shows the hierarchical structure has significant effects on various tasks, such as memory for word lists (Bower, Clark, Lesgold, & Winzenz, 1969), computer programming (Hughes & Michton, 1977), and problem solving tasks (Larkin, 1980; Larkin & Reif, 1979). Tulving and Thomson (1973), however, point out a limitation that hierarchical knowledge structure can enhance recall only when an obvious relationship is established among the different levels of description.

Quillian (1962, 1967) also suggests a spreading activation theory, which considers knowledge access as activation spreading from two or more concept nodes in a semantic network until an intersection is found. In this theory, knowledge structure is not strictly hierarchical. Retrieval or activation of one of the links leads to partial activation of connected nodes. The degree of activation decreases with the distance and time. This theory can explain associative priming by assuming that activation from a word spreads to other words that are semantically associated with the word previously activated (Anderson, 1995). Quillian's spreading activation theory (1962, 1967) is the core process of the modified network model suggested by Collins and Loftus (1975). The model eliminates the hierarchical assumption from network models. Moreover, the modified network model assumes that both concepts and properties can be equally

accessed. That is, differently from Collins and Quillian's model, properties can be directly accessed as concepts. The properties can be also linked to other properties as well as concepts.

However, the network models have a few limitations. First, due to its complex interconnections, specific information in a network may be difficult to retrieve when the network has a lot of information. Second, the consistency of the entire knowledge can be threatened by the interconnection between two knowledge elements that are not consistent with each other because it is possible that each of the knowledge elements can have a relationship with the same knowledge element (Reif, 2008). Last, the network models cannot explain typicality of concepts, which refers to the extent to which an object is a 'good example' of the concepts (Osherson & Smith, 1997). The typicality of concepts issue could be overcome by the feature comparison model.

Feature Comparison Model. The feature comparison model (Smith, Shoben, & Rips, 1974) assumes that concepts are stored with sets of features, not in interconnected hierarchies, and that knowledge is organized based on a feature comparison in a semantic network. There are defining features and characteristic features in the model. Given a concept, defining features are essential for the concept to be classified in a category. Characteristic features, on the other hand, can be usually found in a concept but are not essential for categorization. The feature comparison model also has two sequential steps for inclusion of a concept into a category. At the first step, defining features and characteristic features of a concept are compared to ones of the target category. At the second step, then, all defining features are compared when a decision on association was not made at the first step.

The feature comparison model can be applied to many real world concepts of the fuzzy type (Kintsch & Keenan, 1974). In addition, the model can predict verification times for false sentences and account for errors and account for typicality effect, category size effect, fast rejection, and "hedge" or "sort of like" concepts. The feature comparison model can explain some effects the network model cannot. However, it also has weaknesses because it is not economical and cannot explain semantic flexibility.

Propositional Model. One of the widely accepted models of knowledge structure is the propositional model (Anderson, 1983; Norman & Rumelhart, 1975). In this model, knowledge structure is viewed as an interconnected network of fundamental propositions, which

are the smallest units of information that consists of a node and a labeled connection in a general network model. According to the propositional model, a node in a memory contains a proposition, not a concept. The proposition in a network is flexible because a lot of combinations of nodes and connections in the network can be made. In terms of flexibility, propositional network models seem to have more benefits than hierarchical models that can support superordinate and subordinate relationships. In addition, the propositional model can explain the situation that occurs when people recall propositional structure rather than exact sentence structure after reading a few sentences.

Anderson (1982, 1983) suggests the Adaptive Control of Thought (ACT) model, which is an integrative model that can represent declarative knowledge and procedural knowledge. In the model, declarative knowledge is represented as a network of propositions and procedural knowledge is represented as a system of production. Anderson (1982, 1983) argues that learning procedural knowledge encompasses three phases: the declarative phase, the knowledge compilation phase, and the procedural phase. New information entered in a declarative form is compiled into a procedural form. When retrieving information, the ACT searches the most active chunk in memory. Then, the information is retrieved if it is above a critical point. Otherwise, the information has been forgotten. Since Anderson developed the ACT mode in 1976, he extended the model into ACT* (Anderson, 1983) and ACT-R (Anderson, 1993), which has a unifying framework based on a mathematical approach (Anderson, 1993). The newest version of the model includes not only temporal information, but also images of objects and corresponding spatial configurations and relationships. According to Anderson (1993), the ACT-R model also includes chunks for declarative knowledge, productions for procedural knowledge, a plan for learning new productions, a goal structure for organizing production, and a retrieval system based on activation. In the ACT-R model, each node in the network can be either active or inactive at a certain time. It can be activated by internal stimuli, external stimuli, or indirect stimulation caused by the activity of neighboring nodes. The activation can make changes to the network.

Parallel Distributed Processing (PDP) Model.   The PDP model (McClelland, Rumelhart, & Hinton, 1986) shows more dynamic forms in accessing knowledge because multiple cognitive operations take place at the same time. In the model, all possible pathways

can be searched at the same time because accessing certain concepts is distributed. Parallel processing is the fundamental assumption and the distinctive feature of the PDP model. According to the PDP model, concepts or propositions can be represented by the pattern of connections among neuron-like units in the network (McClelland &Rumelhart, 1981, 1985), not by the units in the network. Therefore, knowledge organization can be enabled by the pattern of connections among units and the pattern of connections is the key to understanding knowledge structure in this model.

When an individual learns new knowledge, inputs from the environment or within the network can activate the connections among concepts. During the activation process, some connections can be strengthened or weakened. At this point, it is necessary to mention the concept of weight, sometimes called strength. The weight represents the strength of connections and determines the amount of effect that a previous concept has on the next concept. The weight can be continuously adjusted through learning. Thus, in the PDP model, learning is viewed as a gradual course of weakening and strengthening connections through revising existing knowledge (Ratcliff, 1990; Schacter, 1989).

The PDP model can account for the multidimensional nature of concepts. Namely, when a person perceives a concept, the person may simultaneously retrieve various related concepts from the person's knowledge. As a result, people can fill in missing pieces of knowledge even when a stimulus is incomplete (Ormrod, 2008).

Schemas. Knowledge can be stored in long-term memory in a form of schemas (Rumelhart, 1980; Rumelhart & Ortony, 1977). While the models discussed so far mainly deal with fundamental knowledge structures that have interconnections of concepts at a basic level, the schemas focus more on schematic organization of event sequences and scenes as complex knowledge. Although Piaget (1926) initially proposed the term "schema", Bartlett (1932) introduced the concept of schemas, also called schemata, to psychology. A schema, as another approach to understand knowledge structure, is similar to network structures, but more task-oriented (Bartlett, 1932; Rumelhart & Ortony, 1977; Sternberg, 2008). Schemas generally refer to connected sets of ideas, including concepts. In psychology, a schema is a frame (Minsky, 1975), a script (Schank & Abelson, 1977), a general knowledge structure that represents a body of knowledge (Klatzky, 1980; Mandler, 1979), a data structure for representing the generic

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concepts stored in memory (Rumelhart, 1980), and an organized structure that exists in memory and that contains the sum of knowledge of the world (Paivio, 1974). The schema helps people not only interpret incoming information, but also pay attention, remember, make inferences, reason, and solve problems. However, it can contribute to stereotypes because the information is difficult to retain if it does not fit established schemas.

Schemas represent relationships among concepts called slots, which are instantiated with certain details to interpret some events. Schemas actively evaluate incoming new information and organize it to fit appropriate schemas. When an individual encounters a certain stimulus, relevant schemas the individual has are chosen and then the individual may modify the interpretation according to the next following stimuli. In other words, an incoming stimulus triggers a schema and contributes to set up expectations for additional information. If the expectations are satisfied, the schema is instantiated. On the other hand, if the incoming information is contrary to the expectations, the schema is alternated into a new one or modified (Driscoll, 2005).

Mandler (1979) discriminates between a scene schema and an event schema, also called a script (Bower, Black, & Turner, 1979; Schank, 1975; Schank & Abelson, 1977). The former is a cognitive representation of what an individual expects to see when viewing a scene and the latter is temporally organized representations of common sequences of events. The major difference between them is that event schemas have temporal organization while scene schemas have spatial organization. However, both schemas are hierarchically arranged and have sets of expectations.

Schank and Abelson (1977) claim that a script consists of slots and requirements about what can fill those slots. The script can help human perform procedural actions and serve as the context for understanding and remembering information from events (Anderson, Spiro, & Anderson, 1978; Bower, Black, & Turner, 1979). Because, however, scripts are not subject to much change, nor do they provide a means for supporting a totally novel situation, they are not flexible as much as general schemas (Schank & Abelson, 1977). Moreover, if a schema violation, which means a situation that a schema triggered by the previous stimulus cannot expect to find anticipated information from following stimuli, occurs while perceiving continuous stimuli, understanding and memory can be hindered (Bransford, 1979). Therefore, establishing and

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refining schemas in appropriate ways are crucial for human to understand events and perform procedural actions successfully.

Activating appropriate schemas positively affect problem solving performance, but inappropriate schemas sometimes can be used as a result of the absence of appropriate schemas or incorrect classification of a problem. Some concepts can be easily confused. Ausubel and colleagues (Ausubel & Fitzgerald, 1961; Ausubel & Youssef, 1963) suggest that comparative organizers, such as concept trees, can be used for helping learners make similar concepts more easily discriminable. The comparative organizers provide a means for systematic comparison of concepts. The researchers argued that the comparative organizer is an effective tool to facilitate learning of unfamiliar and confusable information.

Conclusion. In an attempt to understand how knowledge is arranged, accessed, and used, research on knowledge structure has been conducted from various perspectives, which include network model, feature comparison model, propositional model, parallel distributed processing model, and schemas.

While the first four models focus on fundamental mechanisms of how people organize information in their minds and explain how new information is arranged and accessed, the schema model highlights knowledge structure as an aggregate of knowledge. Both sides are meaningful for understanding the knowledge structure.

The models commonly say knowledge is not isolated, rather related to other knowledge in a knowledge structure. They also agree that an individual who has knowledge organized in an appropriate way can show higher performance. Thus, it might be beneficial to help individuals organize new knowledge in efficient and effective ways.

Factors Related to the Identification of a Research Problem

Research problems, like general problems, might be meaningless unless they are recognized. Recognition of a research problem may occur as a result of an interaction between the incoming information involving a research problem and the cognitive structures of an individual. In other words, the existing cognitive structure of the individual influences the identification of the research problem.

The identification of a problem suitable for further research means recognizing an existing problem and finding gaps or flaws in a research domain (Lubart, 2001). Identifying a

research problem in conducting research is both a challenge (Kerlinger & Lee, 2000; Strauss & Corbin, 1998) and an important decision (Kerlinger & Lee, 2000). According to Kelly (2011), researchers frequently choose a problem, and then review literature to make background and rationale for their decision. However, the researcher argues that this approach is inappropriate and researchers should start with an idea and then review literature to inform and reshape the problem. For this reason, a literature review should be the basis for the identification and articulation of the research problem (Ismail, Yaacob, Kareem, & Nasaruddin, 2009; Kelly, 2011; Levy & Ellis, 2006).

The literature review requires researchers to understand, analyze, evaluate, and synthesize prior studies. However, learners with limited domain knowledge might face difficulty in locating, organizing, and synthesizing problem-related information (Oliver & Hannafin, 2000). Prior domain knowledge influences metacognition (Garner & Alexander, 1989) and cognitive strategies (Hill & Hannafin, 1997) and metacognition influences an individual's ability to evaluate and integrate new information (Flavell, 1979; Hill & Hannafin, 1997). Thus, metacognition and domain knowledge complement each other (Wineburg, 1998).

In addition to the importance of literature reviews and domain knowledge, researchers in the library and information science field have studied information access skills and other factors influencing literature review and problem identification. In the following sections, four major factors affecting novice researchers' ability to identify and articulate research problems will be discussed along with the kinds of models, strategies, and tools that support this ability.

Factors. Identifying a dissertation topic is not easy for many novice researchers (Heiss, 1970) because they may not have sufficient domain knowledge and research skills. Especially, students in education areas may have more difficulties identifying a topic than those in engineering and science fields (Isaac, Quinlan, & Walker, 1992) because the education students are allowed more independence in selecting a dissertation topic (Heiss, 1967, 1970; Isaac et al., 1989). As a result, the quality of the dissertation topics in education is more dependent on students' ability to identify relevant and appropriate topics.

It should not be assumed that novice researchers already know the literature in a domain (Boote & Beile, 2005). If possible, they should be assisted by their mentors or advisors and trained through instructional or non-instructional interventions. There is a significant difference

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between the novice researcher and the expert researcher. The novice researcher means a person who has little experience with real situations and relies on the rules learned through education to function (Daley, 1999), while an expert refers to a person who has specific knowledge and skills attained through experience (Ericsson & Charness, 1994). The experts have not only domain knowledge, but also highly organized structural knowledge, or schemas. They can recognize, articulate, and solve a problem with their organized schemas.

Domain knowledge. Identifying and articulating research problems are an iterative process that requires researchers to perform repetitive refinement of a selected possible problem. Domain knowledge influences the processes of the problem identification (Chi, Feltovich, & Glaser, 1981; Leinhardt & Greeno, 1986) and problem-solving performance (Lee & Nelson, 2005). The repetitive process might include framing a problem through collecting, organizing, and synthesizing information related to the problem. Researchers can refine their initial problems through the process.

However, while expert researchers can easily access, organize, and synthesize the information more efficiently, novice researchers, who do not have sufficient domain knowledge related to a problem and research skills, may have difficulties in such processes (Oliver & Hannafin, 2000). The reason might be that the novice researchers have relatively small and unorganized units of knowledge. In contrast, the expert researchers have not only more knowledge, but also well-organized knowledge. As a result, the expert researchers can use their knowledge more effectively.

Many researchers (Amadieu, van Gog, Paas, Tricot, & Marine, 2009; Benge, Onwuegbuzie, Mallette, & Burgess, 2010; Glaser, Schauble, Raghavan, & Zeitz, 1992; Hill, 1999; Land, 2000; Lyons, Hoffman, Krajcik, & Soloway, 1997; MaKinster, Beghetto, & Plucker, 2002) have investigated the effects of prior knowledge on individuals' ability related to research processes and activities. Low prior knowledge causes difficulty in generating hypotheses, interpreting data (Land, 2000), conducting systematic inquiries (Glaser, Schauble, Raghavan, & Zeitz, 1992), and evaluating information (Hill, 1999; Lyons, Hoffman, Krajcik, & Soloway, 1997; MaKinster, Beghetto, & Plucker, 2002). Benge, Onwuegbuzie, Mallette, and Burgess (2010) argue that doctoral students' ability to interpret empirical articles is influenced by prior domain knowledge, research skill and knowledge, and vocabulary in a domain. Learners who

have low prior knowledge need more mental effort to process information (Amadieu, van Gog, Paas, Tricot, & Marine, 2009) and their learning is impeded by their incomplete prior knowledge (Land & Hannafin, 1997).

Domain knowledge also influences the ways that researchers access relevant information (Allen, 1991; Hsieh-Yee, 1993; MacGregor, 1999; Shiri & Revie, 2003; Wildemuth, 2004). When expert researchers have extensive and systematically integrated knowledge in a domain, they can use relevant knowledge in their mind with minimal cognitive effort (Ericsson & Smith, 1991; Glaser & Chi, 1988). In case of insufficient prior domain knowledge, however, using external resources is necessary for researchers. In such cases, appropriate search tactics are required for the use of external resources. However, search tactics for accessing information change as an individual's domain knowledge changes (Allen, 1991; Wildemuth, 2004). This means that insufficient domain knowledge limits the individuals' performance related to information access. Domain knowledge influences the number of search entries for accessing needed information (Cromley & Azevedo, 2009; Wildemuth, 2004) and the selection of search terms (Land & Greene, 2000). Students who have low domain knowledge need more entries for an information search than those who have high domain knowledge because of their initial use of inappropriate terms (Wildemuth, 2004). MacGregor (1999) claims that learners with high domain knowledge perform more purposeful navigation to access relevant information. It is hard for researchers to find all needed information by one search trial. Thus, they expand the query used in the first search trial to refine the first search results. Query expansion improves the coverage (Segura, Salvador-Sánchez, García-Barriocanal, & Prieto, 2011) as researchers not only formulate queries using search keywords and conditions, but also expand them to improve search results. In this process, familiarity with the search topic affects the performance because a researcher who has knowledge about the topic can use appropriate synonyms for the search keywords (Sihvonen & Vakkari, 2004). Hill and Hannafin (1997) point out a disorientation level in information access. They argue that an individual who has a low level of domain knowledge might have difficulty in accessing relevant information when the individual has a high level of disorientation.

Not all researchers agree that domain knowledge influences information access. For example, from a study on query formulation in information searching, Aula (2003) claims that

experiences related to computers, the Internet, and search engines are more important than domain knowledge when conducting a search to locate relevant information.

      Structural knowledge.   A second factor that influences problem identification and articulation ability, structural knowledge should be considered because it contributes to organizing information (Ge & Land, 2004). Structural knowledge refers to the interrelated representations of declarative knowledge that facilitate procedures (Gagné, 1985) and a type of knowledge that facilitates the translation of relevant domain knowledge into procedural knowledge (Jonassen, Beissner, & Yacci, 1993). Learners with well-organized structural knowledge can efficiently access their domain knowledge and apply the knowledge to a new situation or problem. Moreover, they are likely to suitably organize new information from multiple sources. Thus, novice researchers with poor structural knowledge might encounter difficulty in organizing new information from a literature review in an effort to identify and articulate research problems.

      Metacognition.   A third factor that influences the problem identification and articulation ability is metacognition. If a problem is not clearly defined and given information is not sufficient, identification of a research problem is a type of ill-structured problem. To individuals who have limited domain and structural knowledge, metacognition is necessary for solving the problems (Ge & Land, 2004).

      John Flavell (1971) introduced metacognition as a concept that relates to one's knowledge and regulation of the processes and outcomes of one's own cognitive system. Later, Flavell (1979) classified three types of metacognitive knowledge: (1) knowledge of personal variables, (2) knowledge of task variables, and (3) knowledge of strategy variables. The knowledge of personal variables is knowledge about how a person processes information and about one's own learning traits. The knowledge of task variables is knowledge about the demands and nature of different tasks. Lastly, the knowledge of strategy variables is knowledge about cognitive and metacognitive strategies likely to be useful for carrying out a task.

      In the process to identify and articulate research problems, researchers' ability to evaluate information and to decide the scope of a search is critical for the successful beginning of research. Metacognition, consisting of metacognitive knowledge and metacognitive experiences (Flavell, 1979, 1987), plays a pivotal role in deciding relevant information and search scope (Moore,

1995). It influences the generation of questions and search terms (Hill & Hannafin, 1997; Moore, 1995). According to Azevedo (2005), metacognition influences the effect of computer-based learning environments. It also complements low domain knowledge and system knowledge (Land & Greene, 2000).

Critical thinking, as a form of metacognition (Flavell, 1979; Kuhn, 1999), also can be considered as a factor that influences the ability to identify and articulate research problems. According to Livingston (2009), the lack of critical thinking skills is evident in students' inability to conceptualize a research problem and to synthesize literature reviews. In the same study, it was revealed that many doctoral students had challenges applying their research knowledge to the dissertation process, especially identifying a research problem and synthesizing literature review.

Information access skills.　A fourth factor that influences problem identification and articulation ability is information access skills. Individuals who are in an anomalous state of knowledge (Belkin, Oddy, & Brooks, 1982a, 1982b) have difficulties in recognizing, articulating, and solving a problem. Information needs occur as an individual's knowledge cannot solve a problematic situation. Since many novice researchers do not have sufficient schemas to identify and articulate research problems in a domain, they might try to find information that compensates for the deficiency. However, the result of the information search depends on computer skills (Jacobson, Fusani, & Yan, 1993), and cognitive structure (Allen, 1990). In the previous section, it was shown that many researchers (Allen, 1991; Hsieh-Yee, 1993; MacGregor, 1999; Shiri & Revie, 2003; Wildemuth, 2004; Willoughby, Anderson, Wood, Mueller, & Ross, 2009) argue domain knowledge also influences information access.

It is difficult to access required information in one single search. Selecting search terms and building search conditions are iterative processes (Spink & Saracevic, 1997). For refining or extending initial search results, researchers should use refinement conditions or other multiple sources. Through this process, knowledge about technological features of a system, such as an online library system, and skills to handle the system are critical to attain needed information from external resources. Thus, knowledge and skill to use various technologies influence the performance of information access. The system knowledge affects the use of cognitive strategy (Hill & Hannafin, 1997) and the retrieval of relevant information using the Internet tools (Land

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& Greene, 2000). Land and Greene (2000) also argue that the understanding of search features is crucial to locate relevant information. Hill and Hannafin (1997) claim that inadequate system knowledge limits system use. However, they also argue that developing system knowledge alone is not enough for successful information access. They suggest that it is crucial to lessen disorientation and frustration.

The amount of information and its organized form is another factor that makes access to relevant information more difficult. Too much information provided in unorganized forms makes even professional researchers feel difficulty. Shen (2007) insists that social scientists encounter difficulty in finding information for their research because of the following reasons. First, information is not systematically organized at one place. Second, there is too much useless information on the Internet and the existing search tools are insufficient to gain the relevant information with minimal trials. Last, there are no integrated sources that have information on people with similar research interests and their related activities. These problems can be other factors that affect novice researchers' ability to identify and articulate research problems.

Strategies and tools supporting problem identification. There are a few strategies and tools that support novice researchers' ability to identify and articulate a research problem. These strategies and tools scaffold researchers who have low domain and structural knowledge, facilitate metacognition, and help researchers access relevant information.

Strategies. For scaffolding novice researchers who have low domain and structural knowledge, external modeling and hypothesis tests have been investigated. External modeling is a representation of structure and relationships between concepts and hypothesis tests are manipulations of variables and their relationships to see results of a combination of variables and a relationship. The use of external modeling is effective for facilitating conceptual change and scaffolding low domain knowledge (Mayer, 1999; Shapiro, 2008). The conceptual changes occur through the following sequential interaction with an environment: mismatch of perceived environment and current conception, understanding, fitting with current conception, and application of the new conception (Windschitl & Andre, 1998). Winn (2008) argues that a learning environment that supports construction and tests of hypotheses and reasoning can promote the conceptual change.

On the other hand, metacognition also can be facilitated by immediate feedback (El

Saadawi et al., 2010). Choi, Land, and Turgeon (2005) raise a metacognitive dilemma during meaningful verbal interactions for improving metacognition. The dilemma occurs due to the interrelationship among metacognition, knowledge construction, domain knowledge, meaningful verbal interactions, and metacognition. To facilitate metacognition, appropriate intervention is required at a point of the relationships. El Saadawi and colleagues (El Saadawi et al., 2010) investigated the effect of immediate feedback on cognitive and metacognitive performance in a medical study using an intelligent tutoring system (ITS). From their study, the researchers argue that immediate feedback, as a metacognitive scaffold, has a positive impact on metacognition.

Winn (2008) argues that a learning environment that supports construction and tests of hypotheses and reasoning can promote the conceptual change. The researcher said that learners' conceptual change could be most effectively facilitated when the learners create their own hypotheses, test the hypotheses, and reason test results. Oliver and Hannafin (2000) also claim that hypothesis testing may support learners who have low domain knowledge in not only understanding a problem, but also developing domain knowledge on the problem.

Regarding access to relevant information, Shen (2007) claims that social scientists use certain strategies to gain needed information. The strategies include (a) extracting abstracts to get the parameters of what is happening, (b) tracking citations to find contemporary work, (c) restricting the search to a limited set of sources to finish research within a planned schedule, (d) and avoiding search terms prone to commercial information. An individual who has a low domain knowledge might have more trouble in accessing relevant information (Hill &Hannafin, 1997) because the domain knowledge influences the use of search terms (Land & Greene, 2000; Sihvonen & Vakkari, 2004; Wildemuth, 2004). Therefore, it might be a meaningful strategy to provide the novice researchers with guided terms for information search.

Note taking is another support strategy for learning that has also been investigated in terms of its functions, methods, effects, and combined effects with other interventions, such as reviewing or organizing notes. A few researchers (Dreher & Guthrie, 1990, Katayama, Shambaugh, & Doctor, 2005, Peper & Mayer, 1986, Ward & Tatsukawa, 2003) uncovered the encoding function of note taking. They claim that the act of note taking itself promotes learning by identifying important information (Haghverdi, Biria, & Karimi, 2010), generating and summarizing information for notes (Davis & Hult, 1997, Rabinowitz & Craik, 1986). Some other

researchers (Bauer & Koedinger, 2004, Kiewra, 1985a, 1985b, Kiewra, Benton, Kim, Risch, & Christensen, 1995, Makany, Kemp, & Dror, 2009, Ward & Tatsukawa, 2003) studied on the external memory function of note taking. They emphasize the role of note taking as a product that can be used for later reviews. Many doctoral students might take notes from written materials on their research topics to select and organize the information. The processes and products of note taking can help them to organize and retrieve knowledge. In other words, note taking strategy scaffolds the learners who have low domain and structural knowledge. Some researchers (Bui, Myerson, & Hale, 2013, Katayama, Shambaugh, & Doctor, 2005) have focused more on the note taking methods. Katayama, Shambaugh, and Doctor (2005) compared typing notes with copying and pasting texts by electronic tools. From the study, they found out that typing notes results in higher retention of knowledge compared with copying and pasting texts in an application test. Since typing notes enforces learners to actively participate in learning and involve in deeper comprehension than copying and pasting texts, learners can build more effective knowledge structure. However, typing notes requires learners to have better working memory than copying and pasting texts. Some doctoral students might have difficulties in typing notes due to the similar reason. Bui, Myerson, and Hale (2013) found a possibility of overcoming the difficulties in typing notes. They revealed that taking organized notes leads to higher performance than transcription in a delay test and also that learners who have insufficient working memory can show high test performance when they study their notes. Their study indicates that learners can show higher performance when they have a chance to use and review organized notes.

   Tools.   A few researchers recommend tools, such as concept maps, simulations that support hypothesis tests, and hypermedia, for supporting researchers. Concept maps have been studied as a conceptual modeling tool. Shapiro (2008) insists obvious explanation about relationships among concepts is essential to scaffold poor domain knowledge. Carey (1986) suggests the use of concept maps as a research tool to support researchers' understanding of the flow of knowledge in a domain. From this perspective, Carnot (2006) argues that concept maps can be used as a means to organize literature reviews. Many studies have revealed the effects of concept maps in identifying research problems. Learners who have low prior knowledge can benefit from concept maps (Amadieu, van Gog, Paas, Tricot, & Marine, 2009; O'Donnell,

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Dansereau, & Hall, 2002) in understanding or recalling the main ideas (Ferry, Hedberg, & Harper, 1998; O'Donnell, Dansereau, & Hall, 2002) and understanding relationships among information (Hayes, 1989). Concept maps help learners efficiently process a large amount of knowledge (van Zele, Lenaerts, & Willem, 2004) and provide dual coding (Paivio, 1986). As a result, learners can access their knowledge structure with less cognitive efforts. The concept maps also contribute to the recognition of pattern and relationship among concepts (Slack & Stewart, 1990).

On the other hand, there are different opinions as regards the effects of the concept maps. According to Amadieu, van Gog, Paas, Tricot, and Marine (2009), learners who have low prior knowledge are disoriented by concept maps that have a network structure while learners who have expertise in a domain are not significantly influenced by the representation structure of information (Calisir & Gurel, 2003; Potelle & Rouet, 2003).

Although concept maps allow researchers to access their knowledge structure with less cognitive effort, completed concept maps may not have an impact on solving problems (Markow & Lonning, 1998). According to Jonassen and Ionas (2008), for successful problem-solving or interpretation of a phenomenon, it is necessary for individuals to model causal relationships among the concepts. They claim that the modeling of causal relationships can be facilitated by simulations and modeling tools. From this perspective, in addition to the concept maps, simulations should be considered as another type of tool to facilitate problem identification abilities.

A simulation is a type of cognitive tool. In social science, simulations involve building models by manipulating variables and relationships among them (Berends & Romme, 1999; Perkins, 1991). Lajoie (1993) explains four roles for cognitive tools: (a) support cognitive and metacognitive processes, (b) share cognitive load by providing support for lower level cognitive skills, (c) allow learners to engage in cognitive activities that would be out of their reach otherwise, and (d) allow learners to generate and test hypotheses in the context of problem-solving.

Simulations might be useful for problem identification because they can support the diverse representation of problems. The use of flexible combinations of problem representations can effectively support problem identification abilities (Lee & Cho, 2007; Mumford, Reiter-

Palmon, & Redmond, 1994). According to Jonassen (2003), a problem should be represented in multiple ways for learners with low domain knowledge because when the problem is represented in only one way, they might concentrate on the surface content rather than a conceptual understanding of the problem.

Simulations assist researchers in testing and revising their own theory or hypotheses. Land and Hannafin (2000) insist that the simulations can help learners to test their own theories and reformulate the theories. Hypothesis testing tools support learners with low domain knowledge to organize advanced knowledge (Oliver & Hannafin, 2000) and to facilitate conceptual changes (Winn, 2008). Some researchers (Bennett & Rock, 1995; Hoover, 1994) found that there is a correlation between the formulation of hypotheses and learners' fluency of ideas. The findings might reflect that hypothesis formulation is related to the learners' structural knowledge.

In addition to concepts maps and simulations, hypermedia is suggested as a tool that facilitates metacognition and domain and structural knowledge. Hypermedia facilitate evaluating the appropriateness of information (Marchionini, 1988), and building mental representations (Jacques, Nonnecke, & Preece, 1993). However, not all hypermedia have such advantages. There might some conditions. For instance, learners might encounter difficulty locating relevant information if the structure of the hypermedia has multitudinous access points (Hammond, 1992). In an effort to support novice researchers to locate necessary information for their research, Ismail et al. (2009) suggest a research support tool that provides novice researchers with a search function to find relevant literatures, experts, and terminology.

Conclusion. In spite of its importance, some novice researchers have difficulty in identifying a research problem. Previous studies claim that domain and structural knowledge, metacognition, and information access skills affect their ability related to the identification of a research problem.

In an effort to help novice researchers identify a research problem, various strategies and tools have been investigated. As a strategy to support low domain knowledge, external modeling was suggested. Immediate feedback was uncovered as an effective strategy to facilitate metacognition. Note taking is a helpful strategy for the individuals who have low domain and structural knowledge. Providing a guided search function helps novice researchers access

relevant information. As tools for supporting the ability related to the identification of a research problem, concept maps, hypothesis tests, hypermedia, and search tools for relevant literatures, experts in the field, and terminology were investigated. For effective interpretation of information and a context, novice researchers may benefit from modeling relationships among the concepts. One modeling approach involves the use of concept maps that do not have a complex network structure. It was also revealed that simulations or hypothesis tests, which can provide immediate feedback, support efforts by novice researchers with low domain knowledge to organize advanced knowledge and to facilitate conceptual changes. As a tool for scaffolding information access skills, a search tool for literatures, experts, and terminology is required.

Although some novice researchers do not have sufficient domain and structural knowledge, metacognition, and information access skills, they can be scaffolded by a variety of strategies and tools that can aid their ability. Thus, providing novice researchers with appropriate means helps them overcome the factors negatively influencing their ability to identify research problems.

Information Bases

Some researchers and practitioners have tried to build information bases in the IDT field. The information bases show variety in content, format, and medium. The following sections will describe definitions and characteristics of information bases and explore previous attempts for building information bases in the field.

Definition.   It is necessary to understand the concept of information to define the information base. Groff and Jones (2003) define information as data that have context while knowledge is information that is understood by people and exists in their minds as one of their abilities. Evernden and Evernden (2003) define information as a meaning and interpretation derived from data, while knowledge is the accumulated understanding and learning of an individual, through the interpretation of information and data. Malik (2005) claims that information has an extrinsic meaning while knowledge has an intrinsic meaning.

According to Sambin, Valentini, and Virgili (1996), information bases are sets of information, "provided with a little bit of structure." Kerdeman and Phillips (1993), Kliebard (1993), and Levin (1993) argue that a set of knowledge cannot be a knowledge base unless it has the same purpose as the knowledge has. In this sense, information bases are accumulated

collections of information (Elmore, 1993; Frost, 1986; Sambin, Valentini, & Virgili, 1996).

Characteristics.   The purpose of an information base is to provide users with meaningful information. For this purpose, they not only store content, but also interact with users. To support the interaction, an information base is combined with a management system. When the information base exists in a traditional form, such as books, the management system might be a table of contents or index. On the other hand, when it exists in electronic form, such as hypermedia or software, it might have a more complex management system. A representative management system might be a database management system (DBMS), which processes transactions between a user or an event and a database. Thus, the interaction can be implemented by common features of a database. The common features include storing, retrieving, updating, querying, sorting, manipulating, and reporting of data.

The interaction might include interaction with other information as well as interaction with users. Because information in an information base is interrelated, the relationships among the information may be changed when new information, especially information contradictory to existing information in the information base, is added (Santos, Gu, & Santos, 2011). The interaction of information bases with other information shows that they change over time, that they are not static, and that they keep evolving. Therefore, information bases should have the flexible design structure that can afford the changes to provide users with recent information and knowledge.

For building an information base, a systematic process is conducted. The process includes acquisition, processing, storage, sharing, and management (Groff & Jones, 2003). Especially, information acquisition is a crucial step to build and refine information bases (Santos et al., 2011). The information quality of an information base depends on the results of the acquisition process. Thus, an information base should reflect a process to improve and maintain the information quality at the information acquisition phase.

Information bases in IDT.   Researchers in IDT field have contributed to the progress of the field through filling up research gaps. Some of them have tried to promote knowledge sharing within the area and bridge the gap between research and practice by synthesizing empirical studies and interpreting principles for researchers and practitioners.

Anglin (1991, 1995, 2011), Clark (2012), Saettler (1990), and Schneider (2008)

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contributed to the construction of information bases that contained comprehensive knowledge and information of the IDT field. On the other hand, some researchers and practitioners (Culatta, 2012; Dabbagh, 2012; Fleming & Levie, 1978, 1993; Razik & Ramroth, 1974; Reigeluth & Carr-Chellman, 2009; Richey, Klein, & Tracy, 2010; Romiszowski, 1988) were more interested in building an information base on a specific domain, such as instructional message design, media selection, or instructional design.

Before developing a new tool, it might be an efficient way to examine how previous similar works have been conducted because the strategy can reduce time and costs caused by wrong decision-making. The following parts cover the technologies and procedures used in collecting, organizing, and sharing information for information bases in IDT.

Collection.   Many information bases in IDT (Fleming & Levie, 1978, 1993; Razik & Ramroth, 1974; Reigeluth & Carr-Chellman, 2009; Richey, Klein, & Tracey, 2010; Romiszowski, 1988; Saettler, 1990), still exist in a form of books, rather than electronic formats that use modern technologies, although some of the books are being delivered in electronic formats. This means that the information bases for collecting knowledge and information often use ways that are similar to those used when writing or editing a book. Since the emergence of the Internet and hypermedia, however, researchers in IDT started to use other technologies to collect knowledge and information and manage the knowledge bases and information bases. Culatta (2012), Dabbagh (2012), Learning theories knowledgebase (2012), and Schneider (2008) use hypermedia for building their information bases. For the collection of knowledge and information, however, their approaches are somewhat different in terms of openness to users' participation in the knowledge and information collection processes. While Culatta (2012) and Dabbagh (2012) do not include interaction channels on their information bases to collect knowledge and information, Learning theories knowledgebase (2012) and Schneider (2008) include the channels. Learning theories knowledgebase (2012) includes a web page that has a structured form to submit new theories and models that can be used for it. The users can participate in building the information base through a web-based interaction channel for which hypertext markup language (HTML) and JavaScript are used. Schneider (2008) adopts a more active interaction channel to collect information for the information base. The researcher used Wiki technology, which supports addition, modification, and deletion of content by users, as a

means of information collection. While Wiki technology contributes to building information bases that are flexible and responsive, it can be exposed to risks of content inconsistency, wrong information, and unbalanced content.

Concerning the procedures to collect information for their information base, Razik and Ramroth (1974) explain details on the criteria for the source selection. At first, they periodically conducted a systematic search of bibliographic sources using Educational Index, Psychological Abstracts, Sociological Abstracts, Dissertation Abstracts, International Index, Library of Congress Catalog, and the Educational Resources Information Center (ERIC). For the next step, they reviewed the materials in journals and periodicals that were selected based on their criteria. Then, they reviewed the bibliographies and references in the materials reviewed. Lastly, they performed a systematic search of the card catalog of their institution, State University of New York at Buffalo. For the source selection, they considered the multidisciplinary nature in IDT field. They used not only the quality of research, but also scope, generalization, and representativeness of cross-section in instructional media research as the selection criteria. Older information bases were created in this manner. There have been changes over time in procedures and tools for collecting information, but the basic concepts of systematic search, reviews on criteria, reviews of bibliographies and references, and further searching in related disciplines are applicable to the creation of modern information bases.

Organization. The organization of information bases might depend on the purpose and target users. For helping novice researchers to understand the basic knowledge and the flows of research and practices in IDT field, some historical and comprehensive information bases are organized by topics and a chronicle of the field (Anglin, 1991, 1995, 2011; Saettler, 1990). Other information bases on a specific domain are organized by topics (Clark, 2012; Culatta, 2012; "Learning theories knowledgebase," 2012; Razik & Ramroth, 1974; Reigeluth & Carr-Chellman, 2009; Romiszowski, 1988), principles (Fleming & Levie, 1978, 1993), theories (Richey, Klein, & Tracy, 2010), or design process (Dabbagh, 2012).

For the systematic organization of information bases, some researchers attempted to develop a taxonomy that effectively classifies and comprehensively covers the field. Caffarella and Fly (1992) suggested a taxonomy of the IDT field. Their taxonomy consists of general variables, definitions, and sample elements. They mapped 152 dissertations that were randomly

selected into their three-dimensional model. The first side of the three-dimensional model consists of design, delivery, evaluation, and management. The second side includes instructional design and learning theory. The third side has research, theory, and philosophy. They added general delivery and personnel management to the model while the dissertation mapping. They argued that their model was a rational representation of the knowledge base in IDT field. Their taxonomy contributed to the building of an information base in the IDT field and the finding of gaps in the body of knowledge in IDT. However, their taxonomy is complex and has overlapping elements, such as design, theory, delivery, and management. Thus, it might be inappropriate as an information base tool for novice researchers

   Sharing. In sharing knowledge and information, books are still one of the major media. However, since the emergence of the Internet and hypermedia, some researchers and practitioners (Clark, 2012; Culatta, 2012; Dabbagh, 2012; "Learning theories knowledgebase," 2012; Schneider, 2008) have tried to deliver their information bases electronically through those technologies.

   Dabbagh's instructional design knowledge base is managed by managers who can control processes related to the sharing of knowledge and information. In contrast, Schneider's information base has information collected, organized, and shared by the users. Although it still has a quality issue, it shows a new approach that combines structured categories generated by the founder with unorganized information collected by voluntary contributors. On the other hand, Learning theories knowledgebase (2012) uses a mixed method to share information by allowing users to participate in building the information base and adopting intervention by a manager during the process to add new information to the information base.

   To increase the range of sharing, external resources can be considered. Dabbagh's instructional design knowledge base can be easily located through a Google web search using the search key words, "instructional design knowledge base." Culatta (2012) uses social network services to complement interaction with the users of the information base. On the information base, the practitioner added the *Facebook Like* button to let users see Facebook pages of the information base. Through the social network services, the practitioner can immediately share recent issues and new knowledge. The users can also share their opinion on a specific topic by embedded survey tools and postings. Since such external resources suggest relevant web sites

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based on semantic analysis or existing connections, they can be easily shared within the field or with people who are interested in topics of the field.

   Conclusion. An information base is an accumulated collection of information in a domain. It supports the interaction with users and other information by common database features, which include storing, retrieving, updating, querying, sorting, manipulating, and reporting of data.

   The previous attempts to build information bases in the IDT field provide this study with concrete methods to collect, organize, and share the information of the information bases. Richey, Klein, and Tracy (2010) provide a meaningful scheme to design information bases on instructional design. Razik and Ramroth (1974) show systematic processes on how to select relevant sources that can be used in building an information base. Culatta (2012), Learning theories knowledgebase (2012), and Schneider (2008) provide ways on how to collect, organize, and share new knowledge and information using new technologies, such as the Internet, hypermedia, and Wiki technology.

   In designing the information base tool for this study, I selectively will take advantage of previous work to meet current requirements. Using the contents the previous works dealt with, I can improve the information quality for the information base tool and enhance the content validity of the study.

Summary of Literature Review

   In this chapter, I investigated three bodies of literature: knowledge organization, factors influencing ability related to the identification of a research problem, and information bases. These three areas contribute to the initial requirements definition of a prototype for the information base tool this study develops.

   Through the review of literature on knowledge organization, it was revealed that how well knowledge is organized influences performance and new knowledge should be organized in an appropriate way. For instance, for individuals who have poor knowledge in a specific topic, an effective way to show new knowledge is in hierarchically organized formats, rather than network formats.

   The second section of the literature review explored factors that influence novice researchers' ability related to the identification and articulation of a research problem and

illuminated strategies and tools that can support the ability. The factors include domain and structural knowledge, metacognition, and information access skills. A few researchers suggest external modeling, creating and testing hypotheses, and note taking strategies to scaffold low domain and structural knowledge. Some other researchers claim that learning environments providing immediate feedback can supplement insufficient metacognition. Some studies revealed that guided search with search terms in a domain can supplement insufficient information access skills. Previous studies have also found that concept maps, simulations or hypothesis tests, guided search, and hypermedia are effective tools to help novice researchers identify a research problem.

Lastly, the literature review on information bases covered the definition and characteristics of information bases and previous works in the IDT field for building information bases in the field. The previous attempts are meaningful for building the information base this study will develop in terms of designing the information base, planning development processes including collection, organization, and sharing of information. At the same time, the attempts have also showed limitations. Although the advance of technology improved the ways to collect, organize, and share knowledge and information, the information bases in the field are still in the stage of limited use of the technology and might need to be improved for supporting users in terms of learning. The information base tool this study will develop needs to have functions to support the users as learners by providing quality information in effective ways.

Chapter 3: Research Methodology

The purpose of this study was to develop an information base tool that provides novice researchers with support functions to help them identify possible researchable problems by organizing, representing, and sharing prior research problems, purposes, methods, and results of research studied in IDT field. Although the tool might have a potential to help professional researchers, the study focuses on novice researchers as the target audience. The novice researchers can use the tool to efficiently organize information on research in IDT. The study employed a design and development research design (Richey & Klein, 2007).

Study Design

This study employed a tool development research design among various design and development research designs, because a research support tool was designed and developed through the study. It was expected to find lessons learned from the development process and specific conditions that facilitate the use and effectiveness of the information base tool and contribute to the field of IDT.

Settings

This study was conducted in an IDT graduate program at a large university in Southwest Virginia, with an enrollment of over 30,000 students. Novice researchers in this study were doctoral students in the IDT program who passed a qualifying examination and were preparing to find a research problem or narrow down possible research problems for their dissertations. They usually used online databases to access previous studies that were related to their research problem or research interest.

Participants and Sampling

Three different groups participated in this study: pilot testers, beta testers, and expert reviewers. The first group included two doctoral students and one recent Ph.D. graduate for pilot tests. The second group had five doctoral students and two recent Ph.D. graduates. The second group conducted beta tests in a real environment. The doctoral students in these two groups served as general users in their respective tests. They were selected from the first and second year doctoral students who had passed the qualifying examination and were, at the time of the study, finding a research problem or narrowing down possible research problems for their

dissertations. The recent Ph. D. graduates, as reviewers of the pilot or beta tests, accepted or rejected new information suggested by the general users for inclusion in the information base tool. The reviewers were selected from the alumni group who graduated from the IDT program within the past three years. The third group was an expert group that evaluated the effectiveness of the tool in terms of how it could scaffold low domain and structural knowledge and supplement insufficient metacognition and information access skills. I selected three professional researchers who have doctoral degrees in related fields to serve as expert reviewers.

This study employed a purposeful sampling technique to select participants. Purposeful sampling was used to provide researchers with rich information on the research questions of the study. From the different purposeful sampling techniques that could have been used to select doctoral students for a pilot test and a beta test, the study adopted the typical case sampling in which participants have typical or average characteristics for a specific phenomenon. The selected participants were in need of development of their ability to identify and articulate a research problem to be an independent researcher. In selecting expert reviewers, I considered their research interests including technologies for learning and instruction, system development, and evaluation. Another criterion was if the reviewer is a professional researcher in the field.

Doctoral students were selected because they had the ability of providing me with sufficient information on quality of, and user satisfaction with, the tool. I also expected that the recent graduates would provide information for the improvement of the tool from the testers' perspectives and the expert reviewers would evaluate the effectiveness of the tool based on their expertise in the field.

Ethical Considerations

Although this study had minimal risks to the participants, I had responsibility for the protection of their rights. I employed the following safeguards to protect the participants' rights: (a) I guaranteed confidentiality during the study, (b) I explained the data collection devices and the activities the participants would be involved in, (c) I acquired approval by the Institutional Review Board, (d) I employed a form to receive permission to use data from the participants, and (e) I informed the participants of the option that they could quit their participation in the study and ask me to not use data collected from them.

Procedures

The procedures of this study were based on four components of the ADDIE model, analysis, design, development, and evaluation. Full implementation of the tool was beyond the scope of the study. The study consisted of seven phases: (1) analysis, (2) design and development, (3) pilot testing, (4) revision, (5) beta testing, (6) revision, and (7) expert review. At the analysis phase, I used findings from the literature review for analyzing requirements of the information base tool. For the design and development phase, I developed a prototype for the tool based on the analysis results. I additionally conducted multiple phases of testing or evaluation after the design and development phase. I conducted pilot tests and beta tests and made revisions to fix defects found by those tests. These phases were expected to contribute to the better system quality of the information base tool. The study also used expert reviews to evaluate the effects of the information base tool. The following sections discuss in detail each of the seven phases of the tool development process.

Analysis. The fundamental requirements of this information base tool were not clear because when this study was conducted there were no similar systems in the field. Thus, this study used the lessons learned from literature reviews for analyzing the fundamental requirements.

Through the literature reviews, it was found that domain knowledge, structural knowledge, metacognition, and information access skills influence novice researchers' abilities related to the identification of a research problem and that there are strategies and tools, such as modeling, hypothesis tests, guided search, or note-taking, that can support some researchers' abilities.

Based on these findings, I determined the tool ideally should contain a limited number of specific features. For example, the tool should present a list of research information with relationships in a manner that helps conceptual modeling, facilitates metacognition, and scaffolds low domain and structural knowledge. The tool should be able to represent relationships identified within the research information collected as part of the tool. The representation should also support hierarchical organization of knowledge because the structure has a significant impact on problem solving tasks (Larkin, 1980; Larkin & Reif, 1979). Ideally, the tool also should have a function that supports hypothesis tests to scaffold low domain and structural knowledge and metacognition. However, this study did not develop the hypothesis test function

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since its full development would have required the tool to have all the qualified information in the field; the tool could not report comprehensive test results with the limited information that was within the scope of this study. Instead, I decided the tool should include a reporting function to examine only the research information submitted to the tool in order to identify and report previously investigated experimental variables and their relationships. This function should provide users with immediate feedback, which reportedly has a positive impact on metacognition (El Saadawi et al., 2010). If users can generate their own combination of experimental variables and relationships with the function and reformulate them in diverse forms, the function should support learners with low domain knowledge and help individuals organize advanced knowledge (Oliver & Hannafin, 2000; Land & Hannafin, 2000; Winn, 2008). The tool also should include a guided search function for helping users who have low domain knowledge and insufficient information search skills to access relevant literature since individuals who have low domain knowledge have difficulties in accessing relevant information (Hill & Hannafin, 1997). Because such difficulties can be caused by the limited use of search terms (Land & Greene, 2000; Sihvonen & Vakkari, 2004; Wildemuth, 2004), the guided search function should provide users with appropriate search key words. Immediate feedback that can be provided by guided search function and variable relationship examination function can support individuals who have insufficient metacognitive strategies. In this study, the tool focused on supporting novice researchers' knowledge of strategy variables, which is knowledge about cognitive and metacognitive strategies likely to be useful for carrying out a task (Flavell, 1979) and I expected the immediate feedback could support individuals' metacognitive performance (El Saadawi et al., 2010). Lastly, the study considered a note-taking function for the tool since Haghverdi, Biria, and Karimi (2010) claimed that the act of note-taking itself can promote learning by identifying important information and Davis and Hult (1997) and Rabinowitz and Craik (1986) revealed that generating and summarizing information for notes can improve learning.

Design and development.   Based on the results of the literature-based fundamental requirements analysis, an initial prototype of the information base tool was designed and developed. For designing the tool, I considered three perspectives: (a) functional features, (b) information, and (c) user interfaces.

Functional features.   The tool was designed and developed to include functions

commonly associated with databases, thereby providing users with features for storage, retrieval, updating and editing, querying, sorting and manipulation, and reporting of data. For example, the information base tool was designed and developed to have retrieval and sort functions for modeling, a manipulation function to demonstrate various sets of experimental variables and relationships, a query function for guided search, and storage and editing functions for note-taking. For the modeling, the tool was designed and developed to retrieve and present lists of research information in organized forms with relationship types between the information. Also, the tool was designed and developed to allow a user to explore a concept and then see relevant research information that is sorted by publication year and grouped by relationship types.

Additional features were designed and developed into the tool. A manipulation function for experimental variables and relationships searches for and retrieves research results based on a complete combination of one or more independent variables, a dependent variable, and a relationship between them. This function provides users with immediate feedback and a chance to explore their own combinations of experimental variables and relationships. Because information dealing with related research is stored in the tool, users can see the flow and relationships of previous research that has studied the same combination of experimental variables and relationships. If there is no research information that addresses the same combination of experimental variables and relationships, users might find a research gap in IDT. They can use not only complete combinations, but also incomplete ones, which have just an independent variable with a relationship, a dependent variable with a relationship, or both variables without a relationship. Using the incomplete combinations, they can see effects of a user-selected independent variable, or factors that influence a dependent variable, or any other relationships of the variables.

The literature review indicated that the information base tool should include a guided search function that provides users with guided search terms in the IDT field. Without a guided search feature, novice researchers who have low domain and structural knowledge may have difficulty in accessing relevant literature on a specific topic due to their insufficient knowledge. Although a user may not be familiar with terms in the field, the tool was designed and developed to allow a user to access relevant research information by using search key words provided in selection boxes.

As an aid for encoding information and external memory, a note taking function was also required for the information base. A note taking function was designed and developed to include creation, modification, and deletion of notes. Users can add a new note and modify and delete existing notes.

In addition to the above functions, the tool was designed and developed to accept new contents so its information base can grow. This capability was addressed by including a suggestion function which allows users to suggest specific citations and related information they feel should be included in the information base. It was also important that the new information suggested for inclusion in the tool be reviewed for accuracy before being included in the information base. This need was addressed by including a review function for information suggested by users. This function is for populating the information base and assuring the information quality. A user can suggest new research information that does not exist in the information base and new relationships among existing items in the information base tool. After a user has submitted a suggestion for inclusion in the information base, a reviewer who is an expert in the field can see the suggested new information. If the reviewer accepts the information, other users can retrieve it. As a result, the suggestion and review functions support users' involvement in populating the tool and the information quality assurance.

Information. The quality and quantity of information is a key element of information bases and affects users' satisfaction with available information bases and their intentions to use them (DeLone & McLean, 2003; Petter, DeLone, & McLean, 2008). For the initial information contained in this information base, therefore, this study utilized information previously selected by experts in the field. As a starting point for the identification and ultimate location of the initial references that populated the tool, the study used references found in the book, 'The instructional design knowledge base: Theory, research, and practice', written by Richey, Klein, & Tracey in 2010. The reference information from the book was used to collect research information for the tool. The collected research information was used for initial population of the tool. The research information was analyzed based on the following categories: (a) publication information, (b) addressed concepts, (c) purposes, (d) research problems, (e) methods, (f) results, (g) recommendations for future research, and (h) experimental variables and relationships.

User interfaces. The information base tool was constructed to meet the needs of three

types of users: non-registered general users, registered general users, and reviewers. The tool addresses these needs by providing three distinct modes in the user interfaces for the information base tool. The first mode is for non-registered general users. This group can query the information base and retrieve information on specific concepts from the tool. Another mode is for general users who have registered and signed-in using an individual account. In addition to the information retrieval function available to non-registered users, registered users can contribute new information to the information base by using user interfaces that appear only when a registered user signs in. They can also manage their own collection that has a list of research information and notes for each search. The last mode is the reviewer mode. The reviewer mode includes user interfaces that allow reviewers to accept or reject the information contributions suggested by the registered users. The expert reviewers also can modify the suggested information during the review process. Although it might be practical to have another mode for a system administrator of the information base tool, the administrator mode is beyond the scope of the study. Thus, the information base tool of this study has an unregistered user mode, registered user mode, and reviewer mode.

Prototype development.   The three perspectives discussed above were incorporated into the design of a prototype for the information base tool and the establishment of a web site for the prototype. Within the website I developed functions and user interfaces with HTML(Hypertext Markup Language), Java script, and PHP(Hypertext Preprocessor) to support users' interaction with the information base tool. The study also used MySQL(My Structured Query Language) as a relational database for storing data and information. For the information for the test phases, the study input about 500 references and related concepts that were mentioned in 'The Instructional Design Knowledge Base' written by Richey, Klein, and Tracey in 2010. During the prototype development phase, I conducted three alpha tests, which are preliminary tests of a new software or system by the developers, of the functions and user interfaces of the information base tool.

Pilot test.   After the prototype development, pilot tests were conducted to make the operation of the information base tool's functions and user interfaces more predictable. Two doctoral students participated in the tests as general users and one recent Ph. D. graduate participated as a reviewer. They tested the prototype of the tool, with emphasis on functions and user interfaces. They were given test scenarios and a set of test data for the test. I provided these

materials to prevent the test participants from overlooking necessary test items. After the pilot

tests by the participants, semi-structured email interviews were conducted to collect feedback on

the test. The data were used to see if the functions and user interfaces of the information base

tool met users' expectations and if there were needs to improve it. I also observed the test

situations when test participants agreed to allow such observations. The purpose of the

observation was to triangulate data collected from the email interviews and find additional

meaningful messages that were not mentioned in the email interviews.

Instrumentation.   Since this study needed to collect extensive and organized ideas,

rather than spontaneous opinions at an oral interview, and overcome constraints of time and

space while having recent graduates as participants, I used email interviews as one instrument for

the study. According to McCoyd and Kerson (2006), interviews using emails have a few

advantages like followings: extensive communication, overcoming time and space, and less

social pressure.

For the evaluation of the pilot tests, the study used semi-structured email interviews. For

the interviews, I designed an interview protocol, consisting of questions for general user mode

testers and a reviewer mode tester (see tentative questions in Appendix A).

As an instrument for the field observations, I used field observation notes that consisted

of title, location, date, time, participant name, setting, and observation record. The field

observation notes were used as a method to record participants' behaviors on the information

base tool and problems found during the observation.

Data collection procedures.   After the approval of IRB, I sent emails to ask pilot test

participants to use the prototype of the information base tool. At this phase, I sent an informed

consent form (see Appendix D) to the participants to obtain the participant's consent. I also

provided them with test scenarios and data sets for the test. Since there were general user and

reviewer modes in the information base, I developed two types of test scenarios, one for general

user mode testers and the other one for a reviewer mode tester. Both types of test scenarios

included necessary test items and explained test procedures for the participants. For triangulating

the collected data from the pilot test and finding additional meaningful messages, field

observations were also conducted. For obtaining the agreement for the field observation, I asked

each of the participants if the participant agreed to allow my observations. Only for those who

allowed the observation, I conducted the field observation during the pilot test. After the period

of the pilot tests, I sent an interview protocol to the participants to collect feedback on their pilot

tests. I had email interviews with all of the three test participants and conducted two field

observations because only two of the participants agreed to the field observations.

Test results. I tried to find meaningful messages from the data collected from the email

interviews and the field observations. Because the pilot tests focused on making functions and

user interfaces in the information base tool more predictable, I analyzed the data with emphasis

on finding functional problems and needs to improve user interfaces. The feedback collected

from the email interviews and field observations was categorized into the function and user

interface and then grouped into each menu of the information base tool (See Appendix E).

The feedback discovered some problems related to the functions and user interfaces of

the information base tool. There were two functional problems and several issues related to the

user interfaces that needed to be fixed. The functional problems were malfunction of a 'Confirm'

button on the review page and inability to add a new publisher on the suggestion page. The user

interface issues included difficulties in recognizing buttons, confusion caused by the interaction

processes and design, and personal preferences.

Although some pilot test participants mentioned that the user interfaces of the

information base tool are intuitive and appear to be user friendly, I tried to improve the user

interfaces through the following revision phase.

Revision. After the pilot test phase, the information base tool was revised based on the

results of the data analysis. Since the pilot tests and subsequent revisions aimed at making the

information base tool more predictable, I excluded the feedback on personal preference. Instead,

I focused only on solving functional problems and improving the user interfaces of the tool. The

revision tasks at this revision phase included

- Adding a button for adding a new publisher when the publisher search has one or
  more search results with a partial search keywords
- Making the 'Confirm' buttons in the review menu work
- Improving the processes and user interfaces for the sign-up
- Adding a confirm message after clicking 'Add to My Collection' button
- Improving the user interfaces for the 'Suggestion' menu

- Improving the user interfaces for the 'My Collection' menu and the note taking function

These revisions were necessary for constructing a predictable environment for the next phase, beta tests.

Beta test.   After the pilot tests and revisions, beta tests were conducted to test the information base tool in a real environment and see whether the tool had satisfactory system quality. Five doctoral students, as general users, and two recent Ph. D. graduates, as reviewers, participated in the beta tests. They used the tool and answered the questions in a semi-structured email interview.

Instrumentation.   This study used a semi-structured email interview for evaluating the beta tests. For the email interview, I designed an interview protocol (see Appendix B for tentative questions) to ask about the system quality and effects of the tool. The system quality includes (a) accessibility, (b) customization, (c) ease of use, (d) efficiency, (e) reliability, and (f) system features (Gable, Sedera, & Chan, 2008). I also included questions asking the potential effects of the information base tool on learning and research performance for the interview protocol. According to DeLone and McLean (2003), information quality is another key element that influences user satisfaction and intention to use a system. In this study, I excluded information quality from evaluation criteria because full implementation and population of the information base tool were beyond the scope of the study. However, the beta version of the information base tool did contain sufficient information to allow users to anticipate the potential relevance of a more fully populated tool for their research.

In addition to the email interview, this study employed a web analytics tool to observe participants' online behaviors within the tool, including moving paths and stay duration. Since the beta testers included remote participants, I considered the web analytics tool as an alternative to field observations. The web analytics can be used as one of the structured observation methods since they provide researchers with categorized data and information on users' online behaviors. As one of the web analytics tools, I adopted the Google Analytics since it was free and easy to use. It was expected that I could better understand participants' online behaviors during the test period and triangulate data collected from email interviews. Before starting the beta tests, I added tracking codes for the Google Analytics to source codes of each page in the tool.

Data collection procedures. I sent an email to ask beta test participants to use the information base tool. At this phase, I sent an informed consent form (see Appendix D) to the participants to obtain their consent. After the test period for one week, I sent the interview protocol to the participants to ask about the system quality and effects of the tool.

For collecting analytics data, I generated Google Analytics reports reflecting users' online behaviors during the beta tests. I focused on how the test participants moved within the tool and how long they stayed on each page.

Test results. The results of the beta tests were used to inform revisions to the tool and data were collected from email interviews and web analytics. The semi-structured email interview included eight categories that were already defined: (a) accessibility; (b) customization; (c) ease of use; (d) efficiency; (e) reliability; (f) system features; (g) potential effects on learning and research; and (h) facilitation of the use of the tool. The first six categories were developed to ask about information system quality (Gable, Sedera, & Chan, 2008). Questions in the other two categories were asked to see the potential effects of the information base tool and listen to users' opinions on the possible facilitation strategies for the tool. During the analysis process, I developed an additional category, population strategies for the tool, through the data analysis because some feedback did not belong to any predefined categories (See Appendix F).

There was no feedback on the need to improve the accessibility of the information base tool. For the customization of the information base tool, a participant mentioned using artificial intelligence techniques to improve its customization. It was found that there were needs to improve the ease of the use of the information base tool. Some test participants provided feedback on needs that (a) newcomers to the field might need to understand the relationship between the different theories, models, and practices; and (b) the information base tool should use more descriptive column headings. From the web analytics data, I also found that the test participants spent a longer time suggesting research information than expected (See Appendix H). There was no discovered feedback to improve the efficiency and reliability of the information base tool, but some of the participants mentioned that having more information for the tool and reviewing information by experts could improve its reliability. Pertaining to the system features, a participant suggested making the search pages simpler by hiding a few forms. All the test

participants agreed with the potential effects of the information base tool on learning and research performance, but some of them also thought the quality and quantity of the information in the tool could influence the potential effects. They answered the question asking the potential effects with the following comments: (a) it helped me stay on track with my research; (b) it helped to narrow information down immensely; and (c) if it has lots of related materials, it will help a lot. For facilitating the use of the information base tool, the test participants provided the following ideas: (a) providing a tutorial on how to use this tool; (b) sharing folders with other people of the same interest; and (c) utilizing the information base tool in the courses in the instructional design and technology field. As population strategies for the information base tool, the test participants mentioned that importing initial resources by administrators can make it more helpful and it is a good idea for the learner to contribute to the tool by adding models, theories, and practices. From my prior knowledge of databases and the feedback on the population strategies, it was clear that the information base tool could be populated with both strategies, importing initial resources by administrators and supporting resource addition by users.

From the analytics data collected by the Google Analytics, I found that all the test participants successfully navigated within the information base tool (See Appendix G). The web analytics tool in the study helped me decide if there was a functional problem in the tool and see how much time each test participant spent on each web page. For example, I reasoned that the suggestion page needed to be simplified since the test participants stayed on the suggestion page longer than expected (See Appendix H). The web analytics tool also reported data on the participants' technological environments, such as web browsers, operating systems, and devices. However, the study could not find any useful information on the technological environments from the analytics report.

Revision. The information base tool was revised again based on the results of the beta tests. The activities of this phase focused on improving system quality and effectiveness of the tool. In deciding what feedback could be considered as an item for improving the quality and effectiveness of the tool, I excluded feedback on personal preferences and items that were outside the scope of the study. Based on the beta test feedback, I made the following functional revisions to the tool:

- Developed file import modules to support the initial population

- Developed an additional search function for those who do not understand the relationships among different theories, models, and practices
- Added more descriptive call-out messages for the column headings
- Simplified the suggestion page and made the suggestion process faster

The file import modules were developed to support the administrators as well as users of the information base tool since the file import function would be useful for both groups. The modules support two different file types, xls formats and txt formats. The users can download a template in a Microsoft Excel format from the file import page and upload an updated template file. They can also upload a text file that has a list of references in APA formats.

The quick search function was developed to support those who want to know a concept, but do not understand the relationships among different theories, models, and practices. They may not know if the concept is a theory, model, or practice and can not use the basic search function or the advanced search function that the information base tool provides. Accordingly, for solving this problem, I developed an additional search function, the quick search, using only a concept name as a search condition.

I added more descriptive call-out messages for the column headings of the information base tool. Making the column headings more descriptive was considered, but it took more space on the screen and damaged the design consistency of the tool. Thus, I added more descriptive call-out messages for the column headings, as an alternative way to help users understand the meaning and purpose of each column heading.

Since it was found that test participants used more time than expected on the suggestion page and they also mentioned that the suggestion page needed to be simpler, I simplified the suggestion page and made the suggestion process faster by minimizing mandatory input items and hiding optional items in the suggestion form.

Expert review. At the last phase, three experts in the field reviewed the information base tool. They reviewed the functional features, such as modeling, variable-relationship viewer, guided search, and note-taking functions of the tool with a conscious purpose of evaluating the effectiveness of the tool in terms of providing support for novice researchers in the areas of domain and structural knowledge, metacognition, and information access skills. The results of the expert reviews are presented in Chapter 4.

Instrumentation.   This study used a checklist for the expert review. I developed a checklist for the expert review to ask about the effectiveness of each function of the tool (see Appendix C for tentative items). The checklist included 16 questions asking the effects of the modeling, variable-relationship viewer, guided search, and note-taking functions on each of the following areas: domain knowledge, structural knowledge, metacognition, and information access skills. Each question of the checklist had a four-point Likert scale, from strongly disagree to strongly agree, to have the reviewers to be more discriminating and avoid misinterpretation of mid-point.

Data collection procedures.   I sent emails to ask expert reviewers to use and review the information base tool. At this phase, I also sent an informed consent form (see Appendix D), instructions for the expert reviews, and the checklist for expert review to the reviewers. Since it was difficult to have each expert reviewer conduct the review during the same time period, I collected the data from the expert reviewers over a five week period.

Data analysis.   For analyzing data collected from the expert reviews, I explored the data and tried to find common or similar responses from the reviewers. Because the number of reviewers was small, this study did not use statistical analysis techniques. Instead, the study focused on finding meaningful messages regarding to the tool effects. The analysis results are discussed in the following chapter.

Chapter 4: Findings

The purpose of this study was to develop an information base tool that provides novice researchers with support functions to help them identify possible researchable problems by organizing, representing, and sharing prior research information. The novice researchers, including graduate students, can use the information base tool for organizing knowledge in the field. The study employed a tool development research design (Richey & Klein, 2007) and a modified ADDIE process, consisting of analysis, design and development, pilot test, revision, beta test, another revision, and expert review. For design and development of the tool, I developed a prototype that could be improved through following phases, such as pilot tests and beta tests. Instead of fully implementing the tool, the study adopted pilot tests, beta tests, and revisions based on the test results to improve its system quality. As a summative evaluation, I asked three experts to review the latest version of the tool in terms of the effects of the modeling, variable-relationship viewer, guided search, and note-taking functions on scaffolding domain and structural knowledge and supplementing metacognition and information access skills.

Feedback collected from pilot test and beta test participants contributed to improving the system quality of the information base tool. The prototype of the tool was modified and improved to meet users' expectation. Following the modifications and improvements, a final version of the tool was evaluated by expert reviewers. The following sections include answers to each research question.

Research Question 1: Based on a Review of Relevant Literature, What Features Should Be Included in the Information Base Tool to Support Novice Researchers?

I found that I could use the literature review results to identify the features that should be included in the design of a prototype of the information base tool. I adopted guided search, experimental variable and relationship examination support, conceptual modeling support, and note-taking as major features of the tool since the relevant literature suggested these strategies or tools had positive scaffolding or supplementing effects. I also included functions to support population strategies that are currently being used in other information bases and knowledge bases in the field. I could design the tool prototype and its major features through the review of relevant literature although there were no similar tools in the field and it was hard to elicit

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requirements from potential users.

Research Question 2: How Might the Features Be Operationalized to Support Novice Researchers?

Table 1 compares the requirements from the literature review and the pilot and beta testers with the operationalized features and functionalities of the final version of the tool that was reviewed by the expert reviewers. The contents of the table address each of the theoretical categories derived from the literature review that were incorporated into the final tool.

Table 1.
Comparison of Requirements and Final Tool

Requirements	Final Tool	Basis
Conceptual modeling support	Search Result Page	Literature Review
Experimental variable and relationship examination support	VR-Viewer Page	Literature Review
Guided search	Basic Search Page	Literature Review
	Advanced Search Page	Literature Review
	Quick Search Page	Feedback From Tests
	Research Information Details Page	Literature Review
Note-taking	Note-taking Page	Literature Review
Prerequisites for above requirements	Suggestion Page	Population Strategy
	File Import	Feedback From Tests
	Review Page	Information Quality

First, for the conceptual modeling support, the final tool includes the search results pages that show a list of research information with its relationship with other research information. The relationship can be represented by '~', '< >', or '@'. The '~' symbol is used for representing a relationship between research information that has similar research results. The '< >' symbol describes a relationship between research information that has different research results from each other. The '@' symbol is used for showing a relationship between research information when a research information source cited the other source. In addition to the representation method for search results, the tool also provides users with information on the theories, models, practices, experimental variables and relationships addressed in each of the research information for supporting their conceptual modeling. By an organized form representing those concepts, the tool supports the conceptual modeling.

Second, for the experimental variable and relationship examination support, I developed the Variable-Relationship Viewer. Users can select experimental variables and their relationships

on the Variable-Relationship Viewer page and see a list of research information that uses the same experimental variables and relationships as they select. In other words, they can construct their own combinations of experimental variables and relationships and receive immediate feedback on the results. From this feature, they can examine the flow of research using specific experimental variables and relationships.

Third, the final tool has three different types of guided search functions: the Basic Search, Advanced Search, and Quick Search to help novice researchers access relevant information. The Research Information Details page shows retrieved information on specific research information source. Since there are different needs for the search, the tool includes the three different search functions. The Basic Search can be used for users who want to search research information related to a specific theory, model, or practice. The Advanced Search is for users who want narrow search results down with publication information, theories, models, practices, experimental variables, research purpose, problems, methods, results, and recommendations. The Quick Search can be used for users who want to search research information on a specific concept, but do not know how to use the Basic Search or the Advanced Search with the concept as a search keyword. The Quick Search allows them to enter a search keyword and shows a list of research information that uses the search keyword for addressed theories, models, practices, and experimental variables.

Fourth, for the note-taking support, the final tool includes a feature that helps users add, modify, and delete notes. They can add a new note if an idea comes to mind while they are exploring search results or their personal folders, called My Selection. For modifying and deleting a note, they can use the My Selection. This manipulation with the feature can support their note-taking processes.

Lastly, there are a few pages that were not identified by requirements analysis or test feedback, but necessary for making the tool available to be practically used in real settings. They are 1) Suggestion page, 2) File Import page, and 3) Review page. The Suggestion page is for populating the tool and considered at the prototype development phase. The File Import page was implemented according to feedback from test participants since they wanted to see enough volume of research information sources in the tool when they will start to use it. The page is also for populating the tool. Last, the Review page is for supporting the review processes, which can

assure the information quality of the tool.

Based on a review of relevant literature, the information base tool has a menu structure supporting four major features: the modeling, variable-relationship viewer, guided search, and note taking. Table 2 shows the menu and sub-menu structure and the function for each menu and sub-menu.

Table 2.
Tool Menu Structure and Functions

Menu	Sub-menu	Functions
Search	Basic Search	To search research information by selecting one or more theories, models, or practices in selection boxes
	Advanced Search	To search research information by multiple criteria
	Quick Search	To search research information by a keyword
VR-Viewer		To see previous studies that use a specific experimental variable and relation
Suggestion	Research Information	To suggest a new research information source to the tool
	Research Relation	To suggest a new relation between two existing research information sources
	File Import	To import a large volume of research information sources at one time
My Folder	My Suggestion	To manage suggestion history and temporary saved suggestions
	My Collection	To manage collections and notes
Review		To review and manage suggested research information (Reviewer menu)

The 'Search' menu has three different sub-menus: Basic Search, Advanced Search, and Quick Search. First, the 'Basic Search' is for users who want to search research information by selecting one or more theories, models, or practices. The users can narrow the search results by including the publication period in the search. Second, the 'Advanced Search' is useful for users who want to use multiple search criteria, including combinations of theories, models, practices, purposes, research problems, experimental variables, methods, results, recommendations, author names, publication years, source titles, and publication titles. The users can use the multiple criteria to narrow search results step-by-step. Lastly, the 'Quick Search' is for those who are not sure if a concept is a theory, model, practice, or experimental variable. They can search research information with a concept name without any additional criteria.

The 'VR-Viewer' menu is for users who want to see previous studies that use a specific independent variable, dependent variable, and relationship. VR stands for variables and

relationships. Users can select one or more independent variables, a dependent variable, and a relationship in selection boxes.

The 'Suggestion' menu includes three sub-menus: Research Information, Research Relation, and File Import. First, the 'Research Information' menu is for users who want to suggest a new research information source by inputting a few mandatory or optional items for the suggestion. Second, the 'Research Relation' menu can be used by users who want to suggest a new relationship between two research information sources existing on the tool already. Lastly, the 'File Import' menu is for importing a large volume of research information sources to the tool at one time. The menu supports two different file formats. One of the supported file formats is the xls format used in the Microsoft Excel. The other supported file format is the txt format that can be used in word processors, such as Microsoft Word.

The 'My Folder' menu has two sub-menus: My Suggestion and My Collection. In the 'My Suggestion' menu, users can track the status of their suggestions, modify rejected suggestions, delete their suggestions before reviewers start to review the suggestions, and manage temporarily saved suggestions. In the 'My Collection' menu, users can manage their lists of research information of interest and notes for research information. They also can add a new research information source to their collection from the Research Information Detail page. There are two methods to add a new note. One is to use the Research Information Detail page and the other is to use the 'My Collection' menu. When they use the 'My Collection' menu, they can modify and delete an existing note as well as add a new note.

The 'Review' menu is for reviewers. Reviewers can manage suggested research information with the 'Review' menu by accepting or rejecting suggestions. They can provide users who suggest new research information with feedback on each suggestion within the menu. Appendix I illustrates each page, including functions and processes, of the information base tool.

I designed and developed the operationalized information base tool based on a modified ADDIE process combined with pilot tests, beta tests, and revisions after each of the tests. In the process, test participants contributed to improving the system quality of the tool by providing feedback on the prototype of the tool. I developed the prototype to reflect the literature review results and the final tool included functions and user interfaces to support novice researchers. I employed expert reviews as a summative evaluation for the operationalized tool.

For analyzing data collected from the expert reviews, I explored the data and tried to find common or similar responses from the reviewers. Because the number of reviewers was small, this study did not use statistical analysis techniques. Instead, the study focused on finding meaningful messages regarding to the tool effects. Table 3 illustrates the expert review results.

Table 3.
Expert Review Results

Features	Supported Factors	R1	R2	R3	Description
Modeling	Scaffolding low domain knowledge	3	2	3	2 reviewers agreed
	Scaffolding low structural knowledge	3	4	2	2 reviewers agreed
	Supplementing insufficient metacognition	3	2	2	1 reviewer agreed
	Supplementing insufficient information access skills	4	3	2	2 reviewers agreed
Variable-relationship viewer	Scaffolding low domain knowledge	3	3	3	3 reviewers agreed
	Scaffolding low structural knowledge	3	4	2	2 reviewers agreed
	Supplementing insufficient metacognition	3	2	2	1 reviewer agreed
	Supplementing insufficient information access skills	4	3	2	2 reviewers agreed
Guided search	Scaffolding low domain knowledge	3	3	4	3 reviewers agreed
	Scaffolding low structural knowledge	3	4	3	3 reviewers agreed
	Supplementing insufficient metacognition	3	2	2	1 reviewer agreed
	Supplementing insufficient information access skills	4	3	3	3 reviewers agreed
Note-taking	Scaffolding low domain knowledge	2	2	1	No reviewers agreed
	Scaffolding low structural knowledge	2	2	1	No reviewers agreed
	Supplementing insufficient metacognition	2	3	2	1 reviewer agreed
	Supplementing insufficient information access skills	3	3	2	2 reviewers agreed

Note. R1, R2, and R3 are reviewers. In scales, 1 means strongly disagree. 2 means disagree. 3 means agree. 4 means strongly agree.

Table 4 describes that all the expert reviewers agreed the guided search function could scaffold low domain and structural knowledge and supplement insufficient information access skills. They also agreed the variable-relationship viewer could have an effect on scaffolding low domain knowledge. On the other hand, they thought that the note-taking function could not scaffold low domain and structural knowledge. For the effects of the other features of the tool, the expert reviewers had mixed opinions. Two of the three expert reviewers agreed that the modeling feature could scaffold low domain and structural knowledge and supplement insufficient information access skills, the variable-relationship viewer could scaffold low structural knowledge and supplement insufficient information access skills, and the note-taking

function can supplement insufficient information access skills. Only one expert reviewer agreed that insufficient metacognition could be supplemented by the modeling, variable-relationship viewer, guided search, and note-taking functions.

Table 4.
Summary of Expert Review Results

Functions	Scaffolding		Supplementing	
	Low domain knowledge	Low structural knowledge	Insufficient metacognition	Insufficient information access skills
Modeling	Yes = 2 No = 1	Yes = 2 No = 1	Yes = 1 No = 2	Yes = 2 No = 1
Variable-relationship viewer	Yes = 3 No = 0	Yes = 2 No = 1	Yes = 1 No = 2	Yes = 2 No = 1
Guided search function	Yes = 3 No = 0	Yes = 3 No = 0	Yes = 1 No = 2	Yes = 3 No = 0
Note-taking function	Yes = 0 No = 3	Yes = 0 No = 3	Yes = 1 No = 2	Yes = 2 No = 1

The reviewers thought that low domain knowledge could be scaffolded by the variable-relationship viewer and guided search functions, low structural knowledge could be scaffolded by the guided search function, and insufficient information access skills could be supplemented by the guided search function. Consequently, at least two of the three reviewers evaluated the modeling, variable-relationship viewer, and guided search as the functions that could support individuals who have low domain and structural knowledge and insufficient information access skills. However, at least two reviewers claimed that none of the functions of the tool could support learners who have insufficient metacognition.

Chapter 5: Lessons Learned and Future Directions

The information base tool was developed to provide novice researchers with support functions to help them identify possible researchable problems by organizing, representing, and sharing prior research problems, purposes, methods, and results of research studied in the IDT field. For developing the tool, the study employed a tool development research design (Richey & Klein, 2007). I learned lessons from the research process and results. In this chapter, the lessons learned are discussed and the directions for future research and practical use of the tool are recommended.

Lessons Learned

I used findings from the literature reviews for identifying the requirements of the information base tool and for suggestions about why the requirements are important for novice researchers. The findings from the literature reviews suggested strategies and tools to promote scaffolding knowledge and supplementing metacognition and information access skills within contexts similar to those that might be encountered by novice researchers. At the requirement analysis and the prototype design and development phases, I considered those strategies and tools as major features of the tool supporting novice researchers who are trying to identify and explore a researchable problem by scaffolding their domain and structural knowledge and supplementing their metacognition and information access skills.

Although they had some suggestions for improvement, the pilot and beta test participants were able to use the tool's features without encountering many difficulties. The expert reviewers focused their reviews on the alignment of the features with the support the researcher expected the features to provide. Although all of the reviewers agreed with the alignment of features with supports in some cases, they also disagreed with the alignment of features with supports in other cases. Through the pilot test, beta test, and expert review, I believe that the tool and its features can support the novice researchers in some contexts. In the course of the study, I also learned lessons related to research results and facilitation conditions.

Lessons related to research results. While I anticipated that all the support features in the tool could help novice researchers identify a research problem, not all the expert reviewers agreed that all the features could support the novice researchers. For example, regarding

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information access skills, at least two of the experts agreed that each feature of the tool could supplement novice researchers with insufficient information access skills. For metacognition, at least two experts doubted that each feature of the tool could supplement novice researchers who have poor metacognition. For the other features, there were different responses from the reviewers and the following sections discussed the responses.

Modeling feature. I expected the modeling feature of the tool would scaffold domain and structural knowledge. Two of the three expert reviewers agreed with the effect of the modeling feature of the tool on domain knowledge and structural knowledge. One of the expert reviewers strongly agreed that the modeling feature could scaffold individuals who have poor structural knowledge. This is consistent with studies that argued that the use of modeling is effective for facilitating conceptual change and scaffolding low domain knowledge (Amadieu, van Gog, Paas, Tricot, & Marine, 2009; O'Donnell, Dansereau, & Hall, 2002; Mayer, 1999; Shapiro, 2008). Moreover, it has been revealed that modeling has an effect on understanding or recalling the main ideas (Ferry, Hedberg, & Harper, 1998; O'Donnell, Dansereau, & Hall, 2002) and understanding relationships among information (Hayes, 1989). This study included the modeling feature for the information base tool since scaffolding low domain knowledge, understanding or recalling the main ideas, and understanding relationships among information are important to novice researcher in conducting research.

I also expected the modeling feature would promote metacognition. However, two of the three expert reviewers disagreed that modeling could supplement learners who have insufficient metacognition. In the study, it was not expected that the modeling could affect metacognition by itself. Although on the surface, the modeling does not appear to supplement metacognition, as previous studies discovered (Garner & Alexander, 1989; Wineburg, 1998), domain knowledge can influence metacognition. Thus, it might be reasonable to argue that the modeling can supplement individuals who have poor metacognition by scaffolding their domain knowledge.

Variable-relationship examination feature. I expected the variable-relationship examination feature in the tool could scaffold novice researchers' domain and structural knowledge by allowing them to locate research that used the same experimental variables and relationships as the ones they generated. All the expert reviewers agreed that the variable-relationship examination feature could scaffold novice researchers who have low domain

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knowledge as expected. Two of them also agreed with that it could scaffold structural knowledge. These results are consistent with the literature review which indicated that a tool feature supporting generation and examination of hypotheses, consisting of experimental variables and relationships, could facilitate conceptual changes (Winn, 2008), support learners with low domain knowledge to organize advanced knowledge (Oliver & Hannafin, 2000), and influence the fluency of ideas (Bennett & Rock, 1995; Hoover, 1994).

Guided search feature.   I considered the guided search as one of the major features for the tool because low domain knowledge can influence the use of search terms for accessing relevant information (Land & Greene, 2000; Sihyonen & Vakkari, 2004, Wildemuth, 2004) and make locating needed information more difficult (Hill & Hannafin, 1997). I anticipated that the guided search feature could scaffold novice researchers with low domain and structural knowledge. In addition, I also expected that the guided search feature could prevent novice researchers, who have insufficient metacognition and information access skills, from losing direction while they are searching information and help them be on the track.

All the expert reviewers agreed that the guided search feature could scaffold novice researchers with low domain and structural knowledge and supplement novice researchers who have insufficient information access skills. From the literature review and expert reviews, I found out that providing novice researchers with search support functions can help them by scaffolding their low domain and structural knowledge and supplementing insufficient information access skills. Regarding metacognition, only one expert agreed that the guided search feature could supplement novice researchers with insufficient metacognition. This result is different from what I expected. However, as discussed in the modeling feature section in this chapter, metacognition might be supplemented by the guided search feature since domain knowledge influences it.

Note-taking feature.   It was anticipated the note taking feature can support novice researchers who have insufficient metacognition as seen in the study by Bui et al. (2013), but two of the expert reviewers disagreed with the claim that the note taking feature can supplement novice researchers with insufficient metacognition. In addition, all of the expert reviewers disagreed with the claim that the note-taking feature could scaffold novice researcher with low domain and structural knowledge.

Although the reviewers did not agree with the effect of functions of the tool on metacognition, they agreed that modeling, variable-relationship viewer, and guided search could scaffold domain knowledge. As Garner and Alexander (1989) and Wineburg (1998) claimed, domain knowledge can scaffold metacognition and the domain knowledge and metacognition complement each other. Thus, it might be reasonable to argue that the modeling, variable-relationship viewer, and guided search can supplement metacognition at least through scaffolding domain knowledge.

Moreover, the act of note-taking itself can promote learning by generating and summarizing information for notes (Davis & Hult, 1997, Rabinowitz & Craik, 1986) and identifying important messages (Haghverdi, Biria, & Karimi, 2010). Thus, although two of the expert reviewers responded that the note-taking feature does not supplement novice researcher with insufficient metacognition, it might be meaningful to include the note-taking feature in the tool due to its effects on learning.

Lessons related to facilitation conditions. Feedback from the test participants in the study includes meaningful messages related to the conditions for facilitating the tool. Some of the participants recommended providing a tutorial on how to use the tool and sharing the My Collection with other people of the same interest. First, for eliminating difficulties in using the tool, a tutorial would benefit some users and reviewers since each user has different levels of technological skills and understanding of similar web based systems. Second, for promoting and expanding the use of the tool, sharing the My Collection with other people of the same interest might be effective. Although it is not supported in the tool at this point, it is possible to implement the collection sharing function in the tool since the database for the tool was already designed to support the function. If the function is implemented, users can make research groups and share meaningful information with the members of the groups.

In addition to the above recommendations, the facilitation conditions include the quality and quantity of the research information in the tool. Effective population strategies can be considered as conditions for facilitating the tool. The population strategies include user suggestion for single research information, importing large quantity of research information by users for review, and importing large volumes of research information by reviewers and administrators.

Limitations of the Study

This study used a limited number of participants and reflects the views of a portion of the population of the study. The views of some people in the population may differ from the participants of the study. A part of the population may have different situations in terms of technological and cultural environments. Another group of the population may have different level of domain and structural knowledge.

Another limitation of this study is related to the effects of the information base tool. This study used about 500 research information sources and all the participants experienced the tool with this limited amount of research information. It might be possible to have different results when participants use an information base with more research information.

I employed a limited number of expert reviewers to evaluate the tool and to see the effects of the tool on scaffolding low domain and structural knowledge and supplementing insufficient metacognition and information access skills. Thus, a limitation exists in generalizing the evaluation results.

Future Directions

Implications for future research. The study employed expert reviews for evaluating the tool and it has limitations to generalize the review results. Future research may focus on the use of the tool to see the effects of the overall tool or each feature in the tool. For instance, there was an arguable result in the study, which was that all the experts disagreed with the claim that note-taking feature can scaffold novice researcher who have low domain and structural knowledge. However, their evaluation conflicts with existing studies that investigated the effect of note-taking (Davis & Hult, 1997; Haghverdi, Biria, & Karimi, 2010; Rabinowitz & Craik, 1986).

Moreover, two of the expert reviewers concluded that none of the major features of the tool could supplement novice researchers with insufficient metacognition. However, at least two of the reviewers agreed with the claim that modeling support, variable relationship examination support, and guided search could scaffold novice researchers who have low domain and structural knowledge and a few researchers (Garner & Alexander, 1989; Wineburg, 1998) insist that domain knowledge can influence metacognition. Thus, it might be possible to argue that the features of the tool, except for the note-taking feature, can directly supplement the novice

researcher with poor metacognition and future research might determine if note-taking has an indirect effect on metacognition.

Implications for the practical use of the tool.   The information base tool was developed for a practical purpose, which is to support novice researchers by helping them identify a researchable problem in the field. Therefore, it is important to discuss the practical use of the tool. The multiple features of the tool allow novice researchers to use the tool for various purposes. However, as most participants in the study commented, the tool would be most helpful for novice researchers in the IDT field if the tool has a sufficient volume of research information before it starts its service for the field. Other participants identified the importance of quality information and mentioned that the review process could contribute to assuring the information quality. The potential users recognized that the quality and quantity of the information in the tool are important to make the tool useful. Thus, ensuring the quality and quantity of the research information will be one of the keys for successful use of the tool.

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Appendix A. Email Interview Protocol for Pilot Tests

The following interview questions are for a dissertation study to develop an information base for research in IDT field. This email interview asks your experience of the prototype of the information base. Your response will be confidentially managed and you will have chances to review your response. You also have rights to ask the researcher of this study to change or discard your response. Thanks you for your participation.

Interview Questions

For 'General User' mode test participants

1. Did you find any functional problems when you used the 'Search' menu? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

2. Did the user interface need to be improved or corrected when you used the 'Search' menu? If yes, would you describe the user interface and your ideas to improve it?

3. Did you find any functional problems when you used the 'VR-Viewer' menu? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

4. Did the user interface need to be improved or corrected when you used the 'VR-Viewer' menu? If yes, would you describe the user interface and your ideas to improve it?

5. Did you find any functional problems when you used the 'Suggestion' menu? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

6. Did the user interface need to be improved or corrected when you used the 'Suggestion' menu? If yes, would you describe the user interface and your ideas to improve it?

7. Did you find any functional problems when you used the 'My Folder' menu? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

8. Did the user interface need to be improved or corrected when you used the 'My Folder'

menu? If yes, would you describe the user interface and your ideas to improve it?

9. Did you find any functional problems when you used other menus? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

10. Did any user interfaces need to be improved or corrected when you used other menus? If yes, would you describe the user interfaces and your ideas to improve them?

11. What final thoughts about the information base would you like to share?

For 'Reviewer' mode test participants

1. Did you find any functional problem when you used the 'Review' menu? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

2. Did you find any user interface to be improved or corrected when you used the 'Review' menu? If you did, would you describe the user interface and any idea to improve it?

3. Did you find any functional problem when you used the 'Inquiry' menu? If you did, what is the function that had a problem? In addition, how should the function work to meet your expectation?

4. Did you find any user interface to be improved or corrected when you used the 'Inquiry' menu? If you did, would you describe the user interface and any idea to improve it?

5. Do you have any final thoughts about the information base? Would you share them?

Thank you so much for your participation.

Sincerely,
Kibong Song
Ph.D Candidate, Instructional Design & Technology
Virginia Polytechnic Institute and State University
gibbs@vt.edu

Appendix B. Email Interview Protocol for Beta Tests

The following interview questions are for a dissertation study to develop an information base for research in IDT field. This email interview asks your experience of the prototype of the information base. Your response will be confidentially managed and you will have chances to review your response. You also have rights to ask the researcher of this study to change or discard your response. Thanks you for your participation.

Interview Questions
1. How many years have you studied in the IDT field?
2. Do you have previous research experience in the IDT field?
3. Was the Research Information Base easily accessible? If you had difficulty in accessing it, would you describe your experience and suggest any ideas to improve the accessibility?
4. Did the Research Information Base sufficiently support customization you wanted or expected? If it did not, would you share the insufficient points and suggest any ideas to improve the customization?
5. Was the Research Information Base easy to use? If you had difficulty in using it, would you share your experience and suggest any ideas to improve the ease of use?
6. Did the Research Information Base efficiently work to support your activities on it? If you think it was inefficient, would you describe your experience regarding the efficiency and suggest any ideas to enhance the efficiency?
7. Was the Research Information Base reliable to use? If it was not, would you share why you think so and suggest any ideas to improve the reliability?
8. Does the Research Information Base have system features to meet your needs or expectations? If it does not, would you describe what system features should be improved or newly developed?
9. Was the Research Information Base helpful for learning research information in IDT? Would you explain the reason in detail? If it was not helpful, would you suggest any

ideas to improve it from the perspective of learning?

10. Do you think the Research Information Base affected your performance related to research? Would you share the details of your experience and suggest any ideas to make it more effective for research?

11. Do you have any ideas to facilitate active uses of the Research Information Base?

12. What final thoughts about the Research Information Base would you like to share?

Thank you so much for your participation.

Sincerely,

Kibong Song

Ph.D Candidate, Instructional Design & Technology

Virginia Polytechnic Institute and State University

gibbs@vt.edu

Appendix C. Checklist for Expert Reviews

Research Title:

Development of an Information Base to Support Knowledge Organization for Research in IDT

Review Purpose:

The purpose of the expert review is to examine the effects of the information base system in terms of how it can scaffold low domain and structural knowledge and supplement insufficient metacognition and information access skills.

Checklist:

Please select your rating for the below checklist.

N/A: Not applicable, 1: Strongly disagree, 2: Disagree, 3: Agree, 4: Strongly agree	
Modeling support (The way of representing relationships between research)	
1. The modeling support of the system can scaffold low domain knowledge.	N/A 1 2 3 4
2. The modeling support of the system can scaffold low structural knowledge.	N/A 1 2 3 4
3. The modeling support of the system can supplement insufficient metacognition.	N/A 1 2 3 4
4. The modeling support of the system can supplement insufficient information access skills.	N/A 1 2 3 4
Variable-Relationship Viewer	
5. The Variable-Relationship Viewer function of the system can scaffold low domain knowledge.	N/A 1 2 3 4
6. The Variable-Relationship Viewer function of the system can scaffold low structural knowledge.	N/A 1 2 3 4
7. The Variable-Relationship Viewer function of the system can supplement insufficient low metacognition.	N/A 1 2 3 4

8. The Variable-Relationship Viewer function of the system can supplement insufficient information access skills.	N/A	1	2	3	4
Guided search (Basic, Advanced, & Quick Search)					
9. The guided search of the system can scaffold low domain knowledge.	N/A	1	2	3	4
10. The guided search of the system can scaffold low structural knowledge.	N/A	1	2	3	4
11. The guided search of the system can supplement insufficient metacognition.	N/A	1	2	3	4
12. The guided search of the system can supplement insufficient information access skills.	N/A	1	2	3	4
Note-taking function					
13. The note-taking function of the system can scaffold low domain knowledge.					
14. The note-taking function of the system can scaffold low structural knowledge.	N/A	1	2	3	4
15. The note-taking function of the system can supplement insufficient metacognition.	N/A	1	2	3	4
16. The note-taking function of the system can supplement insufficient information access skills.	N/A	1	2	3	4
	N/A	1	2	3	4

Comments

17. What final thoughts about the information base system would you like to share?

Thank you so much for your participation.

<center>**Appendix D. Informed Consent for Participants**</center>

Title of Research:

Development of an Information Base to Support Knowledge Organization for Research in IDT

Principle Investigator

Kibong Song, Doctoral student at Virginia Tech

I. Purpose

The purpose of the study is to develop an information base tool that provides novice researchers, like doctoral students, with support functions to help them find a research problem by addressing research problems, purposes, methods, and results of research studied in IDT(Instructional Design and Technology) field. The study describes in detail the development procedures, the features of the information base, the conditions for facilitating the use, and strategies for populating the information. It can be anticipated that not only novice researchers but also researchers who are in other related fields will use the information base to examine the flow of research in IDT field and find a research problem.

II. Procedure

You are expected to use the web-based information base this study develops as a pilot tester, a beta tester or an expert reviewer. During the test or review, an online analytics tool will collect information on your online behavior, including page movement path, visit duration, or other online events within the web-based information base. However, the online analytics tool will collect information without any identifying information. After the test or review, you are expected to answer the questions for email interviews. Data for this phase of the study will be collected through the following methods..

    A. email interview

    B. online analytics tool (Google Analytics)

Additionally, if you are a pilot tester and agree with field observation by the researcher, your test situation will be observed. The researcher will take notes on the test situation.

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III. Risks

There are minimal risks to participation in this study. Risks to you are no greater than the risks associated with the use of normal web-based databases. In addition, you have the right to withdraw from participation at any time by notifying the researcher in writing of your desire to withdraw.

IV. Benefits

There are no direct benefits to you for participation in this study. No promise or guarantee of benefits has been made to encourage you to participate. Indirect benefits may include higher efficiency in learning and research for usage of the information base this study develops.

V. Extent of Anonymity and Confidentiality

The researcher will keep all data collected confident. Information gathered from the study may be used in dissertation, presentations, patent registration, and articles in professional journals. However, your name will not be used in any dissertation, presentation, patent registration, or articles and identifying information will be changed so that data cannot be connected to individual. Pseudonyms will be used. Every effort will be made to ensure no identifying characteristics of you will be revealed in any reporting of the data.

Only the researcher and his advisor will have access to the identity information contained in the raw data, while the others, including peer reviewers and committee members, will see only pseudonyms instead of the identity information. The raw data will be destroyed after completing the study. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

VI. Compensation

You will not be compensated for participating in this study.

VII. Freedom to Withdraw

You are free to withdraw from this study at any time without penalty. You are free to not respond to any research situations that you choose without penalty. You are free to request that any discussion transcript of yours be removed from the data set without penalty. There may be circumstances under which the investigators may determine that you should not continue to be involved in the study.

VIII.   Subjects' Responsibilities

I voluntarily agree to participate in the research. I have the following responsibilities: to participate in a pilot test, a beta test, or an expert review for the information base and an email interview including follow-up interview if needed.

I hereby acknowledge the above and give my voluntary consent for the collection and analysis of the following materials (please initial all that apply):

_____   Pilot test for the development of an information base tool

_____ Field observation

_____   Beta test for the development of an information base tool

_____   Expert review for the development of an information base tool

_____   Email interview

You must be 18 years of age or older to take part in this research study.

You will be given a copy of this form for your records.

_____   _____

Participant's Signature   Date

Should I have any questions about this research or its conduct, I may contact:

Kibong Song   679-381-3696   gibbs@vt.edu

Ken Potter   540-231-7039   kpotter@vt.edu

If I should have any questions about the protection of human research participants regarding this

study, I may contact Dr. David Moore, Chair Virginia Tech Institutional Review Board for the Protection of Human Subjects, telephone: (540) 231-4991; email moored@vt.edu.

You will be provided with a complete or duplicate of the original of the signed Informed Consent.

Appendix E. Summary of Feedback from Pilot Tests

Category	Menu	Feedback	Source
Function	Suggestion	Couldn't add a new publisher when the publisher search has one or more search results with a partial search keywords	EI
	Review	One of the 'Confirm' buttons didn't work	FO/EI
User Interface	Sign-up	Took some time to find a sign-up button	FO
		Hard to recognize the sign-up button	EI
	Search	Preferred the back button instead of opening in a new window or tab in the search result screen	EI
		Hard to discern each button to navigate within the advanced search (e.g. 'Previous', 'Next', & 'Search')	FO/EI
	VR-Viewer	Clicked 'Add to My Collection' button two times	FO
		Couldn't recognize a completion of adding a new note	FO
		Took some time to find the 'Optional' button	FO
	Suggestion	Hard to recognize how to add a new publisher name	FO
		Confused by the same design of 'Submit' & 'Save for Later'	FO
		Experienced inconvenience due to pop up window sizes that need to be big enough to show contents	FO
		Preferred the same user interface for adding a new note in the 'My Folder' menu with the search result screen	EI
	My Folder	In 'My Collection', there was an empty box made me think I can add a new note without clicking 'Add a Note' button	EI

Note. FO is the field observation. EI is the email interview.

Appendix F. Summary of Feedback from Beta Tests

Category	Feedback	Source
Accessibility	It was easy to access and has a simple layout	EI
Customization	Artificial intelligence could be helpful for the customization	EI
Ease of use	Newcomers need to understand the relationships between the different theories, models, and practices	EI
	It needs more descriptive column headings	EI
	Participants spent longer time for suggestion than expected	WA
Efficiency	I like the idea of being able to directly access Google Scholar	EI
Reliability	It would be as soon as this tool is full of resources	EI
	Experts' checks can assure the accuracy of the information	EI
	Every process worked without any functional problems	WA
System features	The search page could be simpler	EI
Potential effects on learning & research	It helped me stay on track with my research	EI
	It helped to narrow information down immensely	EI
	If it has lots of related materials, it will help a lot	EI
Facilitation of the use of the tool	Providing a tutorial on how to use this tool	EI
	Sharing folders with other people of the same interest	EI
	Utilizing it in the IDT courses	EI
Population of the tool	Importing initial resources by an administrator to be more helpful	EI
	It is a good idea for the learner to contribute to the tool	EI

Note. WA is the web analytics. EI is the email interview.

Appendix G. Beta Testers' Moving Path Generated by the Google Analytics

From starting pages to 2nd interaction

From 2nd interaction to 5th interaction

From 5th interaction to 8th interaction

5th Interaction	6th Interaction	7th Interaction	8th Interaction
/main/main_user.php 3	/main/search.php 2	/main/main_user.php 2	/main/main_user.php 2
/admini/input.php 2	/main/source.php 2	/user/account.php 2	/rib/admini/input.php 1
/main/search.php 2	/rib/main/search.php 1	/rib/main/source.php 1	/rib/admini...theory.php 1
/rib/admini...cation.php 1	/user/account.php 1	/user/folders.php 1	/user/sugge...actice.php 1
/rib/main/m...n_user.php 1	/user/sugge...theory.php 1	/user/sugge...actice.php 1	/user/sugge...riable.php 1
(+3 more pages) 3	(+5 more pages) 5	(+4 more pages) 4	(+5 more pages) 5

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From 8th interaction to 11th interaction

Appendix H. Duration Time of Visit on Each Page

	379	183	00:01:04	27	29.63%	7.12%
	% of Total: 100.00% (379)	% of Total: 100.00% (183)	Site Avg: 00:01:04 (0.00%)	% of Total: 100.00% (27)	Site Avg: 29.63% (0.00%)	Site Avg: 7.12% (0.00%)
1. /rib/admini/input.php	5	2	00:09:25	0	0.00%	20.00%
2. /rib/admini/rel_theory.php	1	1	00:06:38	0	0.00%	0.00%
3. /main/source.php?src_id=83&menu=1	1	1	00:05:29	0	0.00%	0.00%
4. /user/suggest_practice.php?menu=3	1	1	00:05:15	0	0.00%	0.00%
5. /rib/main/suggest.php?src_id=563&page=&review=2	2	1	00:04:05	0	0.00%	0.00%
6. /main/source.php?src_id=268&menu=1	1	1	00:03:45	0	0.00%	0.00%
7. /main/search.php?s_from_2=1&practice[]=Authentic+&+contextualized+learning=&pub_year_1=&pub_year_2=	2	1	00:03:13	0	0.00%	0.00%

Appendix I. Detail Description of the Final Tool

Basic Search Page

For designing the basic search, as a type of guided search, the study employed a framework for the instructional design knowledge base suggested by Richey, Klein, and Tracey (2010). The framework consists of three different categories, theory, model, and practice, for understanding the knowledge in instructional design and technology.

On the Basic Search page, users can select a database that will be used for retrieving research information. They can use the research information base, which has research information confirmed by reviewers, the My Folder, which has research information managed in personal storage, or both databases. After selecting a database, users can select one or more theories, models, and practices for search. If the users want to search research information that was published in a specific time period, they can refine the search results by setting publication year ranges. Figure I1 shows a page design for the basic search. The page includes call-out messages and instructions to help beginning users easily understand how to use the basic search.

Figure I1. Basic Search Page.

Figure I2 shows the search result page when a user uses the Basic Search. The result page includes search keywords, publication year ranges, and a list of research information. Users can conduct another search by clicking the New Search button, see a list of research published by the author when a user click the author's name, and look into the details of the research information when a user click the source title.

You searched for :
Practice = Advance organizer
Publication Year = From 1960   To 1980

Found **1** result.

Meaning of symbols : @ Cited In, ~ Similar Results By, <> Different Results By   New Search

1   Ausubel, D. (1978). In defense of advance organizers : A reply to the critics. *Review of Educational Research*, 251- 257. (Theory :
     Learning Theory / Model : None / Practice : Advance organizers)

Figure I2. An Example of Basic Search Result Pages.

Advanced Search Page

The information base tool has another search method for users who want to use multiple
search criteria other than theories, models, practices, and publication years. The method is the
Advanced Search in which users can use multiple search criteria by adding additional criteria.
The multiple search criteria can be applied to the search results step-by-step and narrow the
results down.

After selecting a database type that will be used for retrieving research information, users
can select a criterion among theories, models, practices, purposes, research problems,
experimental variables, methods, results, recommendations, author names, publication years,
source titles, and publication titles. Then, they can add another criterion by clicking the '[+]'
button. The Advanced Search will use each search criterion in sequence. Figure I3 shows the
Advanced Search page.

Step 1. Select a database you want to search.
   ⦿ Research Information Base ⑦   ○ My Folder ⑦   ○ All (RIB + My Folder) ⑦

Step 2. Select the first criterion you want to use for search. If you want to add more search criteria,
        click [+] button. On the other hand, if you want to delete the last criterion you added, click [-] button.

Criterion 1	Select ⇕

[+] [-]

Search

Figure I3. Criterion Selection Page for Advanced Search.

Figure I4 is an example of the keyword selection pages for the first search criterion.

Users can select one or more search keywords. The example in Figure I4 used theories as the first search criterion. After selecting keywords for the first criterion, users can move forward or backward by clicking the Next Step or Previous Step buttons.

Figure I4. Theory Selection Page for Advanced Search.

When a user select 'Cognitive Learning Theory' among the theories in the first criterion page and click the 'Next Step' button, the user should see a list of methods that are addressed in research information that addresses the cognitive learning theory. In this way, the following search criterion pages show only a list of options that were addressed in or relevant to research information filtered by the previous search criterion. Figure I5 shows the method selection page, as the second search criterion, but the list of methods includes only qualitative-narrative research method since it is the only method that was addressed in research information that addresses the cognitive learning theory in the research information base.

Criterion 1 : Theory >> **Criterion 2 : Method** >>

You searched for :   New Search
Theory = Cognitive Learning Theory

Method	Qualitative-Narrative research

Previous Step   Search

Figure I5. Method Selection Page for Advanced Search.

Figure I6 illustrates an example of the search result pages in the Advanced Search. It incudes the same elements with the Basic Search result pages. It lists search criteria with keywords used for the search and a list of research information retrieved by the search conditions.

You searched for :
Theory = Cognitive Learning Theory
Method = Qualitative-Narrative research
Found **1** result.

Meaning of symbols : @ Cited In, ~ Similar Results By, <> Different Results By   New Search

> 1   Putnam, R; Borko, H. (2000). What Do New Views of Knowledge and Thinking Have to Say about Research on Teacher Learning?. *AECT Journal*, 4- 15. (Theory : Cognitive Learning Theory,Social Cognitive Theory,Distributed Cognition Theory / Model : None / Practice : Communities of practice,Authentic learning)
> Method : Qualitative-Narrative research

Figure I6. An Example of Advanced Search Result Pages.

Quick Search Page

The study employed the pilot test and beta test to improve the system quality of the information base tool. Through the analysis of the feedback collected from the tests, the researcher found out that some users might want to use a simple search tool that uses only a search keyword without any search criteria. Figure I7 shows the Quick Search page with which users can search research information even when they are not sure if a keyword is a theory,

model, practice, or experimental variable. Users need to input a search keyword and click the search button to search research information.

When you are not sure if a concept is a theory, model, practice, or experiment variable, use the Quick Search function. It will search theories, models, practices, experiment variables, and source titles with the concept.

Figure I7. Quick Search Page.

Figure I8 is an example of the search result pages by the Quick Search. The search result page has a search keyword and a list of research information that uses the search keyword for addressed theories, models, practices, and experimental variables.

Figure I8. An Example of Quick Search Results Pages.

Variable-Relationship Viewer Page

The Variable-Relationship Viewer was developed as a function to help novice researchers examine their own theories consisting of experimental variables and relationships. The Variable-Relationship Viewer can retrieve research information that used the same experimental variables and relationships with the novice researchers formulated in their minds.

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Users should select at least one variable to find relevant research information on the Variable-Relationship Viewer page. They can examine not only a set of independent variable, dependent variable, and relationship with the function, but also multiple sets of variables and relationships. If they select an independent variable on the page, the Variable-Relationship Viewer searches research information that used the variable as an independent variable. Likewise, if they choose only a dependent variable, the search results should include research information that used the variable as a dependent variable. When users do not choose any relationships, the search results include all kinds of relationships. Figure I9 shows the Variable-Relationship Viewer page.

Step 1. Select at least one variable, an independent variable and/or dependent variable. If you press and hold 'CTRL' key (for PC users) or 'Command' key (for MAC users), you can select multiple independent variables.

Step 2. Select a relation. If you do not choose any relation, search results willl include all kinds of relations.

Step 3. If you want to deselect a variable or relation you selected, click [Clear] button.

Independent Variable [Clear]	Dependent Variable [Clear]	Relation [Clear]
Animation Narration	Problem Solving Retention	Associative-Directional-Negative Relationship Associative-Directional-Positive Relationship Associative-Nondirectional Relationship Causal Relationship

Step 4. Click 'Search' button. search

Figure I9. Variable-Relationship Viewer Page.

The search result page of the Variable-Relationship Viewer has information on search conditions, a list of research information with experimental variables and relationships, and other research information related to the search results. Figure I10 illustrates an example of the search result pages by the Variable-Relationship Viewer.

You searched for :
IV = Animation And **DV** = Problem Solving And **Relation** = Causal Relationship

Found **1** result.

Meaning of symbols : **@** Cited In, **~** Similar Results By, **<>** Different Results By   New Search

1   Mayer, R; Anderson, R. (1992). The instructive animation : Helping students build connections between words and pictures in multimedia learning . *Journal of Educational Psychology*, 444- 452. (Theory : Media Theory / Model : None / Practice : None)

Ind.V.	Narration	Dep.V.	**Problem Solving**	Relation	Causal Relationship
Ind.V.	Animation	Dep.V.	**Problem Solving**	Relation	Causal Relationship
Ind.V.	Animation	Dep.V.	Retention	Relation	Causal Relationship

   <> Lin, H ; Chen, T.(2007). Reading authentic EFL text using visualization and advanced organizers in a multimedia learning environment.

Figure I10. An Example of Search Result Pages by Variable-Relationship Viewer.

Note-taking Page

The note-taking function was considered as another major function for the information base tool due to its encoding function (Dreher & Guthrie, 1990, Katayama, Shambaugh, & Doctor, 2005, Peper & Mayer, 1986, Ward & Tatsukawa, 2003), important information identification function (Haghverdi, Biria, & Karimi, 2010), and external memory function (Bauer & Koedinger, 2004, Kiewra, 1985a, 1985b, Kiewra, Benton, Kim, Risch, & Christensen, 1995, Makany, Kemp, & Dror, 2009, Ward & Tatsukawa, 2003). Users can add a note for each of the research information in the tool. They can add the note in the research information details page or the 'My Collection' page. Figure I11 shows the Note-taking page within the My Collection menu.

My Collection

Shannon, C; Weaver, W. (1949). The mathematical theory of communication . Book, - .   [Add a Note]   [Hide Notes]
2014-01-29 10:29:00 [Delete] Communication influences

Mayer, R; Anderson, R. (1992). The instructive animation : Helping students build connections between words and pictures in multimedia learning   [Add a Note]   [Hide Notes]
. Journal of Educational Psychology, 444- 452.
2013-09-25 08:40:12 [Delete] Animation helps students learn

Figure I11. Note-taking Page in My Collection.

The users can add, modify, and delete notes in the Note-taking page. Since there was feedback that a user could not easily recognize the note edition box appears, the researcher modified a design for it to help users recognize it easily. When users click the date and time information for each note, they can see the note edition box. If they click the '[Delete]' button they can remove the note from a list of notes. Figure I12 is the Note-taking page.

Shannon, C; Weaver, W. (1949). The mathematical theory of communication . Book, - .
[Add a Note]   [Hide Notes]

2014-01-29 10:29:00 [Delete] Communication influences

Mayer, R; Anderson, R. (1992). The instructive animation : Helping students build connections between words and pictures in multimedia learning . Journal of Educational Psychology, 444- 452.
[Add a Note]   [Show Notes]

* The mathematical theory of communication

Submit

Figure I12. Note-taking Page.

Search Result Page for Modeling Support

The information base tool can support users' modeling by the representation method for related research sources. The search result page uses symbols to represent relationships between research information sources. First, the '@' symbol means that the research information in the search results was cited in another research information source. In Figure I13, there is an example of the search results that use the '@' symbol. In the example, the '@' symbol represent the Briggs, Gagne, and May's book chapter was cited in the Gropper's book titled '*A behavioral perspective of media selection.*' Second, the '< >' symbol was used for representing a relationship between research information sources that have different research results. In Figure I13, the '< >' symbol was used to show that the Kozma's research includes a result different from the Clark's study. Last, the '~' symbol means a relationship between research information sources that have similar research results. The example shows the Winn's research has a result similar with Clark's article. The obvious descriptions for the relationships among research information sources might help novice researchers understand the relationships of different research and trace the flow of the studies on a specific concept or topic.

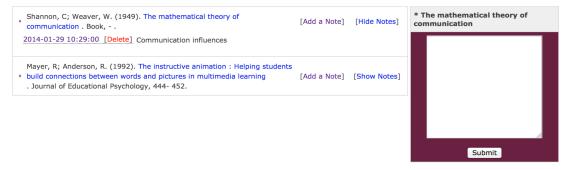Briggs, L; Gagne, R; May, M. (1967). A procedure for choosing media for instruction. In L. J. Briggs, P. L. Campeau, R. M. Gagne, & M. A. May (Eds.). *Instructional media : Aprocedure for the design of multimedia instruction, a critical review of research and suggestions for future research*, 28- 52. (Theory : Media Theory,Social Cognitive Theory,Cognitive Learning Theory / Model : Briggs, Gagne, & May Model,ADDIE Model / Practice : Media selection,Bahavioral objectives,Learning task,Individualized instruction,Grouped instruction,Events of instruction,Task analysis)

@   Gropper, G. L.(1976). A behavioral perspective of media selection.

Clark, R. (1983). Reconsidering research on learning from media. *Review of Educational Research*, 445- 459. (Theory : Media Theory / Model : None / Practice : None)

<> Kozma, R. B.(1991). Learning with media.

~   Winn, W.(1984). Why media? Instructional Innovator .

Figure I13. Representation Method for Related Research Information.

Suggestion Page

   The Suggestion is not a major function of the information base tool, but necessary for its population. The tool adopted two population strategies. One is to import initial information sources by administrators of the tool and the other is to support users to involve in populating the tool by suggesting new information sources. Thus, the suggestion function is essential for the practical use of the tool after importing initial information sources at the early stage.

   For the suggestion, users should conduct a duplication check for the information they want to add to the information base tool. Using the first author's last name and a publication year, the users can see if the new information already exists in the tool or not. Figure I14 shows the duplication check part on the Suggestion page.

Research Information

Step 1. Input the first author's last name and/or publication year to see if there is the research
     information that you will suggest in the Research Information Base.

1st Author's Last Name		Publication Year		Check

Figure I14. Duplication Check Part for Suggestion.

   The next step for the suggestion is to input mandatory items: authors' names, publication year, source title, and publication title. Users can add more authors by clicking the '[+]' button and input optional input items by clicking the 'View Optional Inputs' buttons. Since the research found out that the Suggestion page design needed to be simpler and the time for the suggestion process should be reduced, it was considered that the Suggestion page should have detail instructions, each input item should have call-out messages containing detail descriptions, and the overall page design should be simpler and aligned to make the suggestion process faster. Figure I15 illustrates the mandatory input items on the Suggestion page.

Step 2. Input all required fields to submit the research information. If you want to save the research information for later, you do not need to input all required fields. If you click 'View Optional Inputs' buttons for 'Author', 'Source Title' and 'Publication Title', you can input optional information on each item. You can see help messages when your mouse pointer is on question marks.

(*) : Required field

Author [+] [-]			
(*) First Name ⑦		Initial of Middle Name ⑦	
(*) Last Name ⑦		Suffix ⑦	Select ÷
View Optional Inputs			

(*) Publication Year ⑦		Year

(*) Source Title ⑦	
View Optional Inputs	

(*) Publication Title ⑦	
View Optional Inputs	

Figure I15. Mandatory Input Items for Suggestion.

　　　　The study adopted the Richey, Klein, and Tracey (2010)'s framework for the instructional design knowledge base for designing the information base tool. Their framework includes theories, models, and practices. Some users might not want to input information for these items or do not know what theories, models, and practices were addressed in the research information that they are trying to suggest for the tool. Thus, the tool has these input items as optional input items. Figure I16 shows the theory, model, and practice input part on the Suggestion page. User need to input a theory, model, or practice in a relevant edit box and click the '[Search]' button, then they should know if the theory, model, or practice already exists in the tool or not. When they want to add two or more theories, models, or practices, they can click the '[+]' button.

Figure I16. Theory, Model, Practice Input Part for Suggestion.

The next part for the suggestion includes purpose, research problem, method, result, and recommendation of the research information. Users can input detail description for each of the purpose, research problem, result, and recommendation and select an option for the method. All of the input items in this part are optional input items. Figure I17 shows the research information input part on the Suggestion page.

Figure I17. Research Information Input Part for Suggestion.

The last input part for the suggestion is for experimental variables and their relationships. Users can suggest new independent variables, dependent variables, and relationships for specific research information. They can a set of an independent variable, a dependent variable, and a relationship for both variables. For the relationship, they can select one of the relationships defined by administrators or reviewers. The relationships currently include 1) associative directional negative relationship, 2) associative directional positive relationship, 3) associative non-directional relationship, and 4) causal relationship. Figure I18 shows the experimental variables and relationships input part for suggesting a new research information source.

Figure I18. Experimental Variables and Relationship Input Part for Suggestion.

Research Relation Suggestion Page

In addition to adding a new research information source, it is also important to making relationships among existing research information sources for improving or at least maintaining the system quality and information quality of the information base tool. For supporting users who want to suggest a new relationship between existing research information sources, the tool includes a function for the relationship suggestion. After selecting the first and second sources, users should choose one of the research source relationships: cited in, different result by, and similar result by. When users see search result pages by the Basic Search, Advanced Search, Quick Search, or Variable-Relationship Viewer, the cited in relationship is shown as '@', the different result by relationship is shown as '< >', and the similar result by relationship is shown as '~'. As the research information suggestion, the reviewers for the tool will review the relationship suggestions. Figure I19 illustrates the Research Relationship Suggestion page.

Step 1. For first source title, input a part of or complete title of a source. (e.g. an article)
Step 2. Click 'Search' button.
Step 3. For second source title, do the same process as Step 1 & 2.
Step 4. Choose a relationship type.
Step 5. Click 'Submit' button.

Research Relation

You can see help messages when your mouse pointer is on question marks.

(*) First Source Title ⑦ [   ] 🔍search

(*) Second Source Title ⑦ [   ] 🔍search

(*) Relationship Name ⑦ [Select   ▼]

[Submit]

Figure I19. Research Relationship Suggestion.

File Import Page

The information base tool has another function to add a new research information source besides the Suggestion page. The function is implemented on the File Import page, which was developed for meeting the expectation from the users of the tool since the researcher found out that the users expect the tool will have enough research information when they will start to use it and thought that the amount of research information of the tool can influence the trustworthiness of the tool. Thus, the researcher developed the File Import page for importing a large volume of research information at one time and make the tool able to have enough research information without time-consuming tasks. Each of the administrator, reviewer, and user groups can use the File Import page. Since some users want to add new research information sources from the reference lists for their papers, the researcher made the function available to the users. In this case, the information imported by the users can be reflected on the tool after the confirmation by the reviewers for the tool.

For the file import, the information base tool supports two file formats. One of the supported file formats is the xls format used in the Microsoft Excel. The xls format might be useful for the users who want to manage reference lists for their research papers in the Excel. They can download a template in the xls format from the tool and manage the reference lists with the template. Later, they can upload an updated xls file on the tool without conversion processes. The other supported file format is the txt format, which is commonly usable in many word

processors and text editors. It might be useful for the users who do not want to manage a separate file only for importing research information to the tool since they can export their reference lists in the txt format from their research papers written in other word processor formats and use the exported reference list for importing research information. Figure I20 shows the File Import page.

Step 1. Click mouse right-button and choose "Save Link As" to download a template which is for submitting a lot of research information.
Step 2. Fill in items on the template or copy & paste from other documents.
Step 3. Save the template file.
Step 4. Click 'Browse' button and select the template file you saved.
Step 5. Click 'Upload' button.

Excel File Import   [Template Download]

(*) Excel 97 - 2003 (*.xls)   Browse...   No file selected.

Excel Upload

Text File Import

(*) Text File (*.txt)   Browse...   No file selected.

Text Upload

Figure I20. File Import Page for Uploading a Large Volume of Research Information.

My Suggestion Page

The users who suggested new information for the tool might want to know the status and progress of their suggestion. The information base tool has a function for the users to manage the information suggested by them. They can cancel their suggestion before the reviewers start to review, modify or delete rejected suggestions, and see the status of their suggestion on the My Suggestion page. They can suggest new research information temporary saved in a folder called 'Saved for Later.' Figure I21 shows the My Suggestion page.

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Step 1. You can see a list of research information you have suggested so far.
Step 2. You can also check a list of research information you have temporarily saved on 'Saved for Later' menu.

My Suggestion

‣ Research Info (**523**)

‣ Research Relation (**5**)

‣ Theory (**553**)

‣ Model (**109**)

‣ Practice (**449**)

‣ Variable (**2**)

‣ Saved for Later (**0**)

Research Information

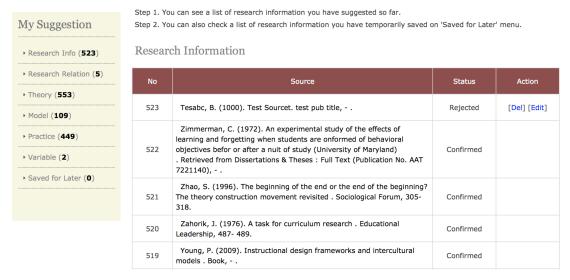| No	Source	Status	Action
523	Tesabc, B. (1000). Test Sourcet. test pub title, - .	Rejected	[Del] [Edit]
522	Zimmerman, C. (1972). An experimental study of the effects of learning and forgetting when students are onformed of behavioral objectives befor or after a nuit of study (University of Maryland) . Retrieved from Dissertations & Theses : Full Text (Publication No. AAT 7221140), - .	Confirmed	
521	Zhao, S. (1996). The beginning of the end or the end of the beginning? The theory construction movement revisited . Sociological Forum, 305-318.	Confirmed	
520	Zahorik, J. (1976). A task for curriculum research . Educational Leadership, 487- 489.	Confirmed	
519	Young, P. (2009). Instructional design frameworks and intercultural models . Book, - .	Confirmed	

Figure I21. My Suggestion Page.

Research Information Details Page

The users of the information base tool can see detail information on a research information source from a search result. When users click a source title, they can see the Research Information Details page, consisting of author information, publication information, and addressed theories, models, and practices. On the page, users can access the full text for a source when they or their affiliation has a right to access it or when the full text is open to public. For user convenience, the tool has a button to access the full text using the Google Scholar. The tool sends the parameters for searching information to the Google Scholar and the Google Scholar retrieves the search results from its system. Moreover, they can add the source to the My Collection and add a note for the source to the My Collection on the page. When they know additional theories, models, or practices addressed in the source, they suggest them on the page by clicking the Add Theory, Add Model, or Add Practice buttons. Figure I22 shows the Research Information Details page.
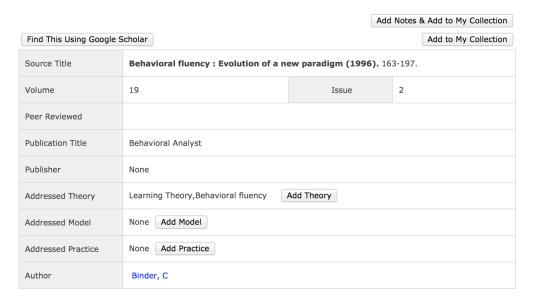
Source Title	**Behavioral fluency : Evolution of a new paradigm (1996).** 163-197.		
Volume	19	Issue	2
Peer Reviewed			
Publication Title	Behavioral Analyst		
Publisher	None		
Addressed Theory	Learning Theory,Behavioral fluency [Add Theory]		
Addressed Model	None [Add Model]		
Addressed Practice	None [Add Practice]		
Author	Binder, C		

Figure I22. Research Information Details Page.

Sign-up Page

The information base tool has a sign-up page for general users who want use all functions the tool provides. The study minimized the number of mandatory input items for the sign-up. The sign-up page requires users to input an e-mail that will be used as user account identification, a password for the account identification, and their names. In addition, the page asks users if they are 18 years of age of older to intentionally avoid inclusion of minority during the alpha and beta tests. This mandatory input item can be removed from the sign-up page when the tool will be populated and used by people.

The researcher included some optional information on the sign-up page for future use. One of the test participants mentioned that it would be good to share the 'My collection' information with other users who have the same research interest. The optional input information might support that kind of online activities that can happen later. Figure I23 shows the Sign-up page.
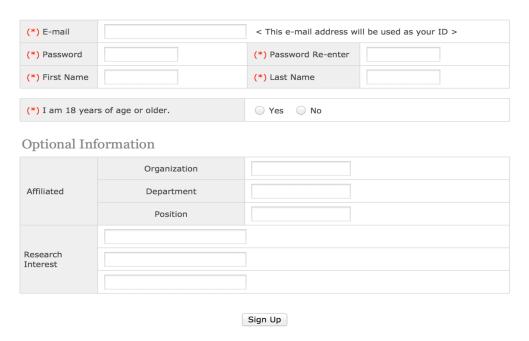
Figure I23. Sign-up Page**.**

Review Page for Reviewers

Since system quality includes information quality, the study tried to find devices to assure or improve the information quality of the information base tool. One of the devices is to have review processes for the information suggested by users. The review page includes functions to help the reviewers conduct the review process. Figure I24, G25, and G26 show the Review page for the reviewers. If the reviewers confirm the suggested information, the tool makes the new information public and other users can see it, whereas they can edit the suggested information by themselves or reject it with feedback on the suggestion when they judge the suggested information needs to be improved. For sending feedback to the user who suggested the rejected information, the tool provides the reviewers with an email template generated from the review results for each item of the suggested information. As a result, the reviewers can send the email without any changes for the body of the email or modify it as needed. Figure I27 shows the Email Feedback page.

Back to Results   Confirm   Reject

Date	2014-03-17 19:47:48

☐ **Author** [Add or Delete]				
First Name	David	Middle Name		[Edit]
Last_Name	Jonassen	Suffix		
Affiliation				
Department				

Figure I24. Author Information Part in Review Page**.**

☐ **Source** [Edit]			
Source Title	Review of Literature on Problem Solving		
Publish Year	2009	Month/Day	
Volume		Issue	
Page Range(From)		(To)	
Peer Reviewed			

☐ **Publication** [Edit]	
Publication Title	Learning & Science
Publisher	Address :

☐ Addressed **Theory** [Edit]	
☐ Addressed **Model** [Edit]	
☐ Addressed **Practice** [Edit]	

Figure I25. Publication and Addressed Theory, Model, and Practice Parts in Review Page**.**

Research Information [Edit]	
Purpose	
Problem	
Method	
Result	
Recommendation	

☐ **Variable** [Add or Delete]

Back to Results   Confirm   Reject

Figure I26. Research Information and Experimental Variables Parts in Review Page.

Email feedback on this suggestion to the suggester	
Subject	[Research Information Base] Feedback on your suggestion
Message	Your suggestion was rejected for the following item. Review of Literature on Problem Solving(2009). Source .... Need to be improved Publication .... Need to be improved Theory .... Need to be improved Model .... Need to be improved Practice .... Need to be improved Author .... Need to be improved Research .... Need to be improved Variable .... Need to be improved

Send & Reject

Figure I27. Email Feedback Page.

The reviewers for the tool review not only new research information sources, but also newly suggested theories, models, practices, experimental variables, and relationships for existing research information sources in the tool. Figure I28 illustrates an example of the Review pages for newly suggested theories, models, practices, and relationships for existing sources in

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the tool. The reviewers can input a review result, add more theories, models, practices, and relationships, or delete reviewed suggestions on the page. Figure I29 shows the Review Status Change page for inputting a review result.

Model

No	Source	Suggested Model	Status	Action
3	Briggs, L; Gagne, R; May, M. (1967). A procedure for choosing media for instruction. In L. J. Briggs, P. L. Campeau, R. M. Gagne, & M. A. May (Eds.). Instructional media : Aprocedure for the design of multimedia instruction, a critical review of research and suggestions for future research, 28- 52.	**ADDIE Model**	Need Review	[Input Review Result] [Add More Models] [Delete]
2	Briggs, L; Gagne, R; May, M. (1967). A procedure for choosing media for instruction. In L. J. Briggs, P. L. Campeau, R. M. Gagne, & M. A. May (Eds.). Instructional media : Aprocedure for the design of multimedia instruction, a critical review of research and suggestions for future research, 28- 52.	**ADDIE Model**	Need Review	[Input Review Result] [Add More Models] [Delete]
1	Keller, J. (2010). Motivational design for learning and performance : The ARCS model approach . Book, - .	**Motivational Design Model**	Need Review	[Input Review Result] [Add More Models] [Delete]

Figure I28. An Example of Review Pages for Theories, Models, Practices, and Variables.
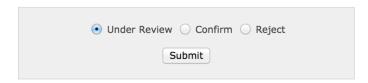
Review - Model

⦿ Under Review ◯ Confirm ◯ Reject

Submit

Figure I29. Review Status Change Page.